INDUSTRIAL PSYCHOLOGY IN GREAT BRITAIN

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PREFACE

THE scope of this book is sufficiently indicated by its title, and my obligations by its dedication. Its construction is as easily explicable. Five lectures delivered by me at Columbia University, New York, form its basis; with the substance of these I have incorporated much new matter. I have placed within brackets paragraphs which may be omitted on first reading.

Figures 1, 2, 3, 6, 8, 9, and 10 have been taken or adapted from the *Reports of the Industrial Fatigue Research Board*: Figures 4, 5, 7, 11, and 12 from the *Journal of the National Institute of Industrial Psychology*. I have to thank the Controller of His Majesty's Stationery Office for granting me permission to reproduce the former, and the proprietors of *The Strand Magazine* for similar permission in the case of Figure 13.

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Chapter 1

ORGANIZATION

INDUSTRIAL Psychology is an applied science. It is concerned in applying our knowledge of mental processes to the conditions obtaining in modern industry. The term 'industry' here covers the problems arising in any recognized occupation – in industry proper, in commerce or among the professions; it will be often convenient to use the term 'worker' in an equally broad sense, regardless of his status.

Industrial Psychology thus covers a wide field. It deals with the human, as contrasted with the mechanical and economic, aspects of labour. Its chief aim is to reduce needless effort and irritation and to increase interest and attention throughout the workers in industry. It is concerned with the study, *inter alia*, of –

(*a*) the psychological relations between labour and management,
(*b*) the incentives to work,
(*c*) the arrangement of the worker's material and the nature of the implements with which he works,
(*d*) the posture and the movements of the worker,
(*e*) the training and the selection of the worker,
(*f*) the distribution of periods of rest and work,
(*g*) the physical environment of the worker,
(*h*) psychological factors influencing the sale of products, e.g. advertising, designing, salesmanship, etc.

Most of these subjects of Industrial Psychology have

been studied experimentally; and illustrations of the quantitative data thus obtained will be given later in this book. Certain other themes, in close relation to the foregoing, are amenable only to observation and are but just beginning to receive systematic attention, e.g. the psychological study of the financier, the director, the shareholder, the consumer, and of federations or associations of employers and workers, and the comparative study of these in different occupations and in different countries. Such topics, treated from the psychological standpoint, belong to the wider field of Economic Psychology.

It should be early recognized that Industrial Psychology does not attempt to draw any distinctive line between psychology and physiology. 'Psychology' is here used to embrace not only the study of mental processes but also the study of those bodily processes that accompany, result from, or affect mental processes. Just as physics involves mathematics, just as physiology – the study of the living body – involves chemistry and physics, so psychology – the study of the living mind – must involve physiology. The higher sciences involve the lower; and in this respect psychology, the most recent and the most complex of the biological sciences, is the highest of them all.

[At one time, under the influence of the philosophers, psychologists were prone, perhaps unduly, to emphasize the distinction between mind and body, and hence held either that mind and body were two distinct enti-

ties each of which might act upon and influence the other, or that they were two parallel manifestations of an unknowable *tertium quid*. But the later progress of psychological, biological and physical science seems likely to reduce this apparent contrast or gap between mental and bodily activity. On the one hand, psychoanalysis, whatever its exaggerations and defects, has undoubtedly served to emphasize the *mental* characteristics of unconscious processes, and to diminish the importance of consciousness when the entirety of our life – conscious and unconscious – is taken under review. On the other hand, biology is recognizing more and more clearly the insufficiency of blind mechanism, devoid of something analogous to the purposiveness and direction of mind, to account for the existence and the evolution of vital processes; while, at the furthest extreme from psychology, the physicist is now expressing, with apparent success, what to the common man appear to be the most distinctively 'material' properties of matter in terms which are immaterial in character. On such ground the mergence of much of industrial physiology with industrial psychology, as here advocated, appears justifiable.]

In the development of Industrial Psychology in Great Britain, two Bodies have been chiefly concerned: (*a*) the Industrial Fatigue Research Board, established in 1918 under the joint auspices of the Department of Scientific and Industrial Research and the Medical Research

Committee (now Council); and (*b*) the National Institute of Industrial Psychology, founded on an entirely voluntary basis in 1921.

The Industrial Fatigue Research Board was appointed as the result of communication between the Secretary of State for Home Affairs and the Department of Scientific and Industrial Research and the Medical Research Council. Both of these Bodies are immediately under the direction of the Privy Council. In December, 1917, they were invited by the Home Office to appoint a Committee for a comprehensive investigation of Industrial Fatigue. This invitation arose out of the disbandment of the Health of Munition Workers' Committee, which from 1915 to 1917, during the Great War, had carried out valuable pioneer investigations in munition factories upon hours of work in relation to output, lost time, etc. When, at the end of 1918, the Industrial Fatigue Research Board was formed, its terms of reference were 'to consider and investigate the relations of hours of labour and other conditions of employment, including methods of work, to the production of fatigue, having regard both to industrial efficiency and to the preservation of health among the workers.'

The Board lost no time in beginning its investigations. It issued its first Annual Report in May, 1920, in which reference is made to four reports already published by it, – dealing with the effects of different hours of work and different conditions of ventilation in muni-

tion and tinplate manufacture, movement study in an iron foundry, and industrial accidents – and to three reports in preparation – on efficiency and fatigue in the iron and steel industry, on the speed of adaptation to altered hours of work, and on individual differences among operatives in the cotton industry. Many other investigations by the Board were by then in progress – into the iron and steel industry, the cotton industry, the boot and shoe industry, the silk industry, the laundry industry, into the principles of time and motion study, vocational selection, etc.

In the following year, at the end of January, 1921, the Medical Research Council, through which the expenses of the Board were now paid, was informed by the Treasury that owing to the financial condition of the country, the work of the Board must cease. The investigators accordingly received notice of the termination of their appointments. But so vigorous a protest against such false economy arose in various quarters, particularly from among the Labour Members of Parliament, that shortly afterwards the Board was reconstituted with a smaller staff, more directly under the control of the Medical Research Council, and with the following modified terms of reference – 'to suggest problems for investigation, and to advise upon or carry out schemes of research referred to them from time to time by the Medical Research Council, undertaken to promote better knowledge of the relations of hours of labour and of other conditions of employment, including methods

of work, to functions of the human body, having regard both to the preservation of health among the workers and to industrial efficiency: and to take steps to secure the co-operation of industries in the fullest practical application of the results of this research work to the needs of industry.'

The Board now consists of eleven (unpaid) members, representative of physiology, psychology, engineering and industry, one of its members being a woman, another Assistant Secretary to the Home Office, and another the General Secretary of a prominent Trade Union. The more executive part of its work is delegated to ten Committees, on to which various prominent scientific and industrial persons have been co-opted. The actual research of the Board is carried out partly in the field of industry, and partly in University laboratories to workers in which salaries or grants are payable by the Board for services rendered.

The paid investigators of the Board conduct most of their inquiries in factories, and the over thirty reports already published by the Board deal with general problems, more especially concerning the metal and engineering industries, the textile industries, the boot and shoe industry, the pottery, laundry, and glass industries. They deal with such subjects as the comparison of different systems of shifts, the effects of rest pauses and of atmospheric conditions, the analysis of individual differences in efficiency, movement study, weight-lifting, the causation of accidents, etc.

On the initiation of an investigation in a special industry, representatives of that industry, both employers and workers, and often one of H.M. Inspectors of Factories, are asked to serve on a special committee. Such Assessors and Panel Members have proved invaluable in securing facilities for investigation and in criticizing the investigators' reports before publication.

Certain investigations carried out by the Board are now receiving the collaboration of the Department of Scientific and Industrial Research, which was originally, as the Medical Research Council still is, its parent body. Thus the Board and the Department are cooperating in an investigation into the design of machines from the physiological as well as from the mechanical standpoint, and in an investigation into illumination.

Research has been carried out by the Board in conjunction with one of the various Research Associations which have been established in different industries by the industries themselves, aided by subventions from the Department of Scientific and Industrial Research. The Board is also conducting investigations on behalf of the Treasury, Home Office, the Post Office, and the Department of Mines.

The relations between the Industrial Fatigue Research Board and the National Institute of Industrial Psychology are intimate and harmonious. Each body is mutually (though not officially) represented on the other; investigators have been loaned or transferred from one body to the other according to need; and they have of

late collaborated in a joint research into vocational guidance. The most recent policy of the Board is not so much to investigate intensively certain conditions in any one industry, but rather, in a thorough and more comprehensive manner, to study general problems of common interest to all industries. On the other hand, the principal objects of the National Institute of Industrial Psychology are to carry out investigations at the request of individual industries or firms or (as in the case of vocational guidance) on behalf of individual persons, to train and to promote the training of investigators in industrial psychology throughout the country, and not only to carry out research in the subject but also to spread a popular knowledge of such research and to indicate its value by lectures to employers, managers and workers, as well as by publications.

With this object the Institute was established in 1921, thanks to the financial support initially obtained from various firms and private individuals and to the promise of a yearly grant of £1,000 for five years, since renewed (and increased) for another five years, received from the Trustees of the Carnegie United Kingdom Trust, the funds of which are used to assist undertakings having as their aim the promotion of the well-being of the masses. In the statement of accounts for 1924 it appeared that over £4,000 were received by the Institute during that year as subscriptions, donations, and advisory and consultation fees, and that over £5,500 were received from firms for services rendered

by the Institute's investigators. The sums received for such investigations during 1924 exceeded those recorded for the previous year by nearly 50 per cent.

The main work of the Institute may accordingly be ranged under five heads:

1. The study of the workers' movements, arrangement of material, arrangement of hours of work and rest, lighting, ventilation, methods of payment, increase of interest, reduction of monotony and worry, relations between labour and management, etc.

2. The study of the abilities required in various industrial and commercial occupations, and the elaboration of systematic methods including suitable tests, so as to secure more efficient selection of employees, and more reliable guidance for those choosing their occupation. A special grant of £6,000 over two years (apart from the two grants already mentioned) has been made by the Carnegie Trustees expressly to further a comprehensive scheme of research on which the Institute is just embarking in order to demonstrate the value of scientifically conducted vocational guidance.

3. The provision of courses of training, partly by lectures given by the Institute's staff at the London School of Economics, and partly by applied practical work in factories and in the vocational guidance section of the Institute, framed to meet the requirements of the examinations for the newly established Academic Diploma in (Industrial) Psychology of the University of London. Shorter courses are also being given by the

Institute to teachers, at the request of Education Authorities, to training college students and others, including employees of firms who will later carry out work in offices or factories under the immediate supervision of the Institute's staff of investigators, who subsequently pay periodic visits to the firms with this object. Lectures and demonstrations are also given publicly, to societies or in factories throughout the United Kingdom; and a Journal is published by the Institute, of which 5,000 copies of each number are at present printed, so as to promote popular interest in the subject.

4. Research work, e.g. on vocational psychology (on which £1,500 was spent by the Institute in the third year of its existence), on lighting, advertisement, etc. This work is being carried out not only in factories, but also in schools (e.g. under the London County Council), and in University laboratories (at Cambridge, London, Manchester, etc.) either by the staff of the Institute or by research workers especially selected for this purpose by those in charge of these laboratories.

5. The study of factors influencing the sale of products, e.g. advertising, salesmanship, designing, variations in taste, etc.

The difference between the work of the Board and the Institute is reflected in certain differences in attitude (*a*) of the employers in regard to the investigators of the Board and of the Institute and (*b*) of the investigators in regard to the employees. The Board's investigators are each concerned with some one special problem; the

employer does not pay for the research on this problem which is being conducted in his factory; the investigation tends to be carried out with the detailed deliberation of the 'pure' research worker; and its results are liable to be withheld from publication for many months (or even years), until sufficient data on the subject have been accumulated by that investigator or by others elsewhere, and the report has been well considered by one or more committees of the Board. In the case of the Institute, on the other hand, the employer realizes that he is paying for the services of its investigators, and they in turn realize the desirability of producing more immediate results, and of not restricting their attention to any one problem, but rather of studying the worker both from a wider and from a closer aspect.

Thus while the Board's investigator may be compared to a specialist interested in a single disease, the Institute's investigator is comparable rather to the general practitioner who is concerned with the general health and the whole constitution of his patient.

But whether an inquiry is being carried out by the Board or by the Institute, it is always of the nature of research. In no two investigations, even upon precisely the same topic, are the conditions identical. If an inquiry is to attain practical success, each factory or office must be individually studied, as the constitution of each individual patient has to be studied by his physician. Just as in medicine prescriptions cannot be

borrowed indiscriminately, the remedies of Industrial Psychology cannot be applied without careful inquiry.

[Thus the investigations into breakages, so successfully carried out for one firm by the Institute, proved inapplicable when later a similar investigation was conducted by it for another firm; and the work on 'buffing' – the polishing of spoons and forks – carried out by the Industrial Fatigue Research Board afforded little help when the Institute became engaged on an apparently similar investigation into the buffing of celluloid articles such as combs. Not only in this respect is each industrial investigation a research, but it is continually looking to the pure sciences of psychology and physiology for guidance; and it is, at the same time, continually revealing wide gaps in their knowledge, and suggesting important problems for laboratory research. The ideal of the Institute is periodically to release each of its investigators for purer research so that those who so desire can work out any problem or problems, suggested during their applied work, in which they are especially interested.]

A useful illustration of the close connection between factory and laboratory research is afforded by the work carried out by two of the Institute's investigators in the Psychological Laboratory of the University of Manchester, upon themes immediately arising from their investigations in a neighbouring coal-mine into the problem of lighting. Attention was directed to the visual after-effects which are produced in the miners

after the miner's lamp has been shining directly into their eyes. This frequently happens during a change of position, the miner passing in front of his lamp about forty times a minute, when shovelling into a 'tub' or 'hutch' the coal 'picked' from the coal face, with the lamp immediately before him. Experiments were carried out by the Institute's investigators, using a standard electric miner's lamp in the dark-room of the Laboratory. Their object was to ascertain the number and duration of these after-images, first according to the position of the miner's lamp relative to the direction of regard, and secondly when the transparent glass cylinder of the miner's lamp, which enclosed the electric bulb with its filament, was rendered slightly opaque by painting it with hydrofluoric acid. The results obtained by the first of these two series of experiments need not detain us; they suggested the second series. Here it was found that while for a given length of exposure to the glare of the ordinary lamp, with its naked filament, the average number of after-sensations was 3·4 and their average duration was 48·4 seconds, with the slightly opaque cylinder the average number of after-sensations was reduced to 1·7 and their average duration to 23·8 seconds.

So far as could be ascertained, no such research had been hitherto conducted. And a similar state of ignorance was found to prevail, when the investigators were confronted with the next problem – would visual acuity suffer in the pit, and if so to what extent, if the slightly

opaque cylinder were introduced, with a consequent loss (owing to diffusion) of physical intensity of light amounting to 28 per cent.? To answer this question the visual acuity of thirty miners was tested in the dark-room under careful experimental conditions, the test objects being illuminated, now with the ordinary transparent, now with the new, slightly opaque, cylinder of the miner's lamp. In the case of fifteen of the thirty miners, their visual acuity was actually better with the diffused but less powerful light; in nine miners it was the same for both forms of lamp; in only four was it better with the ordinary lamp. (Two miners were omitted from consideration owing to their exceptionally bad vision.)

Clearly these results of 'purely' psychological experiment call for yet further research to account for them. But their immediate outcome was the introduction of the modified form of lamp into the coal mine, where it has been appreciated by the miners not only because of the increased comfort of illumination, but also on account of the remarkable reduction of shadows cast by the lamp. It has also led to considerably greater output, especially when combined with greater candle-power.

[The growing recognition of the importance of Industrial Psychology is reflected in the recent establishment of a Diploma in the subject by the University of London. Industrial Psychology is also an optional subject of examination for the degree of Bachelor of Commerce in the same University. Courses of instruction for the

Diploma are provided in London throughout the year at University, King's and Bedford Colleges, and (in Industrial Psychology) at the London School of Economics and at the National Institute of Industrial Psychology, the teachers at the two last-named institutions being mainly members of the staffs of the Institute, and of the Industrial Fatigue Research Board. At Cambridge a paper and a practical examination in Industrial Psychology form one of the optional subjects for the ordinary B.A. degree. The Cambridge course of lectures on Industrial Psychology, extending over two terms, is recognized by the Special Board of Economics and is attended by students who are reading for the Economics Tripos, as well as by those who are reading for Part II (Psychology) of the Moral Sciences Tripos. In the Universities of Aberdeen and Manchester, Industrial Psychology is one of the optional subjects for the degree of Bachelor of Commerce. In Manchester, as in London, the course is attended by persons employed in industry as well as by University students. At Aberdeen the examination and the course of instruction include practical work, e.g. on the work curve, economy of effort, time and motion study, vocational tests, etc. In the University of Edinburgh a course of lectures is given on Applied Psychology, a considerable portion of which is devoted to problems of Industrial Psychology; this course is compulsory for candidates for the Diploma in Education. At the same University, Psychology and the Organization of Industry are

optional subjects for the degree of Bachelor of Commerce, and a special course of lectures is given in relation thereto. An Honours B.Sc. course in Psychology has just been instituted at Edinburgh, of which the last year may be devoted to Industrial Psychology.]

When the National Institute of Industrial Psychology was being established, it was obvious that the workers were straightway prejudiced against it by such terms as 'efficiency' and 'scientific management.' By improvement in efficiency they feared speeding-up and the dismissal of their less competent comrades. The mention of scientific management made them suspect that all their craft knowledge would pass from them into the hands of their employers and that they would be degraded to the position of servile mechanisms. They could quote passages from Taylor's *Principles of Scientific Management* or from his *Shop Management*, such as his remark, admittedly 'in rather rough talk' to 'the little Pennsylvanian Dutchman,' Schmidt, while Taylor was instructing him so effectively in the best methods of handling pig-iron – 'You know just as well as I do that a high-priced man has to do exactly as he's told from morning to night,' or that 'no worse mistake can be made than that of allowing an establishment to be looked on as a training school, to be used mainly for the education of many of its employees,' but that the worker must 'bear in mind that each shop exists, first, last and all time, for the purpose of paying dividends to its

owners.' Such remarks will pass muster only in conditions where labour is unorganized and where an endless stream of foreign immigrant workers is available.

So too Taylor's endeavour to establish 'rigid rules for each motion of every man,' followed by Gilbreth's 'Quest of The One Best Way' and the Taylorian ideal that managers should assume 'the burden of gathering together all the traditional knowledge which in the past has been possessed by the workman,' is in diametrical opposition to the attitude of British workmen. Undoubtedly, their intuitive opposition can be shown to have a sound psychological basis. For the mental and bodily differences between workers are such that it is impossible to train, or to expect, each worker to perform the same operations in identically the same way. In all sport and in all forms of art, there are different styles, all equally good, some suited to some men, others to others. So it must be in regard to industrial work. There *is* no 'one best way.' What the psychologist and physiologist insist is that there are undoubtedly bad styles and bad habits of work which the worker needs to be taught to avoid, and that it is an egregious error to force all workers into a common mould, regardless of the individual differences between them. Gilbreth's notion of 'the one best way' is not only impossible strictly to carry out in practice, because no two persons can be trained to precisely the same features of rhythm and movement, but it may also be harmful to the worker because it tends to discourage initiative.

The National Institute has endeavoured to base its ideals on sound psychology rather than on the superficial analogy with a piece of engineering mechanism. It has sought not to press the worker from behind, but to ease the difficulties which may confront him. It has aimed at removing the obstacles which prevent the worker from giving his best to the work; and it has almost invariably succeeded in increasing output by this method. By adopting such procedure it has gained the confidence of the worker. He feels that here is an impartial investigator spending several months in his workshop, living more or less nearly the worker's own life, endeavouring to eliminate needless movements and wasteful energy, and endeavouring to study the mental influences and the incentives which affect the worker's efficiency and contentment. Indeed sometimes the mere presence of the Institute's investigators and the interest which they have shown in the employees' work have served to send up output before any actual changes have been introduced. How widely removed is this psychological attitude from that of the so-called 'efficiency experts' whose engineering training and consequently mechanistic attitude lead them rather to time-study the worker as if he were a machine, to set hourly or daily tasks which an efficient worker should be expected to perform, and to devise elaborate systems of payment which, in their mistaken belief that prescribed tasks and proffered bonuses are the main incentives to production, will induce the worker to give his best.

No one can deny the power of the incentive of payment, but it is far from having the supreme importance which some ascribe to it. A recorded instance will illustrate this. A certain factory offered wages approximately 50 per cent. higher than those paid in another. This offer was well known to, and freely discussed by, the workers in the latter factory. Moreover, a trade boom existed, so that workers were scarce and the risk of unemployment was slight. But not a single worker left the second factory for the first, the reason for this being that whereas the one firm had a good reputation among the workers, the other had not. This example will serve as a warning against over-exaggerating the undoubted importance of payment as an incentive. The worker is not necessarily comparable to the imaginary donkey who will run only when a carrot is placed in front of his nose, and run the faster the larger or the more quickly moving the carrot. Men may continue to work when they are rolling in wealth: they may continue to loaf when they are wellnigh starving from poverty.

Even piece-rate systems of payment will often fail to provide the incentive to production with which they are usually credited. The worker may fear that if he earns too much, the piece-rate will be lowered, and that he will be held responsible by his comrades for such rate-cutting. Class loyalty and the fear of unemployment are potent causes of restriction of output even when the workers are paid by results.

At least as important, then, as methods of payment is

the mental atmosphere of the works, the character of which is largely dependent on management and leadership on the one side, or loyalty and comradeship on the other, and on the satisfaction of each worker's instincts and interests, which are by no means confined to what money will buy him outside the factory. In this connection it is well to consider the different effects on the mental atmosphere of a factory produced by the following types, by no means exhaustive, which have been actually observed by an investigator of the Industrial Fatigue Research Board among managers and foremen on the one hand, and among workers on the other. Among managers, foremen and the like, this investigator recognizes first the egoistic, emotional type, who, as she puts it, 'reacts not to the reality of the situation but to the emotion aroused in him by that situation.' His extreme egoism is always likely to be hurt and his *amour propre* wounded by his subordinates. He is therefore apt to be unjust and to lack balanced criticism. His influence on his subordinates is obvious. 'Some are kept in a state of nervous tension fearing the next outburst . . . others of robuster mould become indifferent either to praise or blame.'

A second type of manager is the over-anxious one, who is never right in his own eyes and for whom consequently nothing can ever appear right. He is always grumbling and finding fault with his subordinates, who consequently can find no pleasure in their work and live in an atmosphere of depression.

Yet another type is the manager who has some absorbing interest, e.g. in tidiness, or some absurd prepossession, e.g. that if the foreman or supervisor is not busy with his hands, he is not working. Such a one's subordinates pander to his whims; 'it pleases him,' they say, 'and it doesn't hurt us.' But if they please him in this respect, they feel at liberty to please themselves in other really important matters, and consequently again a bad state of discipline tends to prevail.

These three types present a vivid contrast to the ideal manager, who lacks the sensitiveness and emotionality of the first type, the over-anxiousness and lack of reliance of the second, and the ridiculous prepossessions of the third, who can nevertheless 'get angry at slackness and bad work, and whose treatment of others is guided by principle, sympathy and humour.'

Just as there are recognizable types of men who are unfitted for the work of management and foremanship, so we may distinguish types of men unfitted to act *primarily* as subordinates; primarily, because we must bear in mind that few people are not at one moment subordinate to some persons, and at another master of others. There are three main causes of conflict between the worker and his industrial surroundings. The management may be unsatisfactory; the worker may not find the kind of subordinate work congenial to him; or he may suffer from inadequate opportunity for the development of self-assertion. The first cause of conflict we have been considering; of the second we shall

treat in the last two chapters; in relation to the conflict involved through a self-assertive person being forced into a subordinate position, the three following types have been recognized:

First, the truculent worker who objects to an order simply because he is in the position to receive it. Such a person develops a habitual grievance, is hard to manage, and leaves his job on apparently inadequate grounds.

Secondly, the worker whose spirit of self-assertion has been broken, who takes no interest in his daily work but acts as if he were a machine. Such a one is apt to satisfy his longings by recourse to pleasant imagination or day-dreaming. For him no repetitive task, however monotonous, is felt as such. So long as he is not asked to alter his methods or to attend to new details, he remains happy.

Thirdly, there is the worker who satisfies his self-assertiveness or desire for leadership by taking a leading part in social activities, e.g. sport or games, outside his industrial life.

But we have always to bear in mind that industrial life occupies less than one-third of the worker's total hours and that conflict with industrial conditions may be a reflexion of conflict with domestic ones, as well as being the outcome of inherited tendencies or of bygone experiences, especially in childhood or adolescence.

Clearly, therefore, it becomes the function of the industrial psychologist not merely to investigate methods

of payment, the movements of the worker, and the length of hours of his work, but also to attempt to improve the mental make-up of the worker, to study his home conditions and to satisfy his native impulses, so far as they are satisfiable under modern industrial conditions where, despite longer education and increasing culture, industrial specialization tends to reduce him to the status of a small wheel working in a vast machine, of the nature of which he is too often kept in complete ignorance, and towards which consequently he is apt to develop apathy or actual antagonism.

In recent times, the pendulum of psychological opinion has probably swung too far to the extreme that regards man's conduct as the mere mechanical resultant of opposing impulses warring among each other, in which the ego itself – however we may regard its nature – plays no part. Nevertheless, the unconscious conflict and unsuccessful repression of thwarted instincts and unexpressed emotions in industry, to which so much attention has generally been directed of late years, undoubtedly deserve close study. For we now realize that the worker's repressed feelings tend to reappear as unpleasant phantasies in waking life, or in dreams, in some disguised form. They may reappear through the agency of 'inversion,' as when cowardice manifests itself as foolhardiness; or through 'sublimation,' when they become transferred from one object to some different, often higher, object; or through 'projection,' when they

become attached, e.g. as accusations, to some other individual instead of being applied, as originally, to one's own self.

When such defence mechanisms fail or are inadequate the worker becomes beset with worry, distracted by discontent. Under these conditions not only is he incapable of giving his best, but he is liable to a far wider range of disorders than is generally accredited to mental causes. Evidence is accumulating that the occupational neuroses, e.g. telegraphists' cramp and miners' nystagmus, are by no means ascribable solely to such factors as posture or illumination: the mental factors of worry and anxiety play an important, perhaps the essential, rôle in their causation. So also many disturbances of the circulatory, respiratory and digestive systems are primarily of mental origin. Psychoneurotic conditions, psychasthenia, neurasthenia, and the like are by no means, as they used to be regarded, the prerogative either of those engaged in intellectual work or of the leisured classes. Frequently the bodily and the mental causes of ill-health are so intertwined as to be almost inextricable. In other words, we cannot separate mental health from physical health. When environmental influences affect the one, they are apt to affect the other. Recognition of this fact cannot fail to enlarge the horizon of the industrial psychologist's outlook, and to obtain the sympathetic co-operation of the worker.

So completely has the National Institute of Industrial

Psychology won the confidence of the workers by its standpoint and by its methods, that they have frequently pointed out to the investigators other lines of inquiry which could advantageously be conducted. They have assisted the investigators by their own suggestions, or, as in the case of an investigation into breakages, by affording information as to how spoilt work arose. They have several times thanked the investigators because, despite increased output, they have returned less tired from their work at the close of the day. And they have demanded of their employers an increased number of the improved implements which have been introduced by the Institute with the object of abolishing needless effort on the part of the workers.

Greater difficulty, perhaps, has been experienced by the Institute in dealing with employers and with their managers and foremen than with the workers. The employer in Great Britain is far more disposed to value secrecy than is his competitor in the United States. He believes that he possesses valuable trade secrets, which can easily be stolen and employed to advantage by rival firms. On these grounds he is prone to shut his eyes to the inefficient state of his factory and to resent the intrusion of an outsider. He may raise the bogey of trouble with Trade Unions, but no such trouble has ever yet been encountered by the Institute in the five years of its varied work. He may have already suffered at the hands of some efficiency expert who, after spending a few hours in the works, has written a verbose,

relatively useless report and has charged a correspondingly high fee. For such reasons he cannot be induced to foresee the possibilities of an investigation, extending over several months, carried out by persons adequately trained in the principles of psychology and physiology, whose first step is, as it were, to soak themselves in the life of the factory, by personally engaging in the work which they are studying. The employer is apt to ridicule the notion that investigators, knowing little initially of his industry, can afford him help. He may fail to realize the special advantages of calling in such trained investigators from outside, whose impartiality appeals to the worker with whom they have to come into contact, whose past experience in other factories, whose freshness of outlook, freedom from authority and tradition, and whose independence of interdepartmental etiquette enable them to make recommendations which any of the factory staff would be unable to propose in the same circumstances.

Just as it is usually the more progressively minded employer who invites the services of the Institute, so it is the more progressively minded manager or foreman who accords its investigator the most cordial welcome. He regards the investigator as a helpful collaborator, as a consultant or specialist in matters of which he cannot be expected to have expert knowledge, not as a critic who is likely to disparage him in the eyes of his director. Without the sympathetic co-operation of management and labour the industrial psychologist can do little. He

must be prepared to allow management to claim as their own suggestions and innovations which are really due to him. He must work in the spirit that, provided working conditions are improved in industry, it matters little who receives the credit for them.

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[1] For brevity's sake the initials *R.I.F.R.B.* and *J.N.I.I.P.* will be used here and in later references for the *Reports of the Industrial Fatigue Research Board* (H.M. Stationery Office) and for the *Journal of the National Institute of Industrial Psychology* (329, High Holborn, London), respectively. The number of a report or volume of any Journal follows in italics, the number of the page in Roman figures.

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Chapter 2

INDUSTRIAL FATIGUE

IN approaching this subject, it will be well first to summarize our slender knowledge of muscular and mental fatigue derived from laboratory experiments. They have provided us with evidence that each striated muscle fibre, when stimulated, responds by an 'all or none' contraction; that is to say, if the stimulus is but sufficiently strong to produce a contraction, the muscle fibre contracts to the same extent, however strong be the stimulus. It is supposed that different muscle fibres within any one muscle show different degrees of irritability, so that varying strengths of stimulus will excite varying numbers of fibres, the degree of contraction of the whole muscle thus being determined by the number of muscle fibres which are at that moment in a state of contraction.

We have experimental evidence that the muscle fibres while at rest secrete within them a store of material in the form of glycogen, ready to break down, on the application of a suitable stimulus, into lactic acid, carbon dioxide, etc., a decomposition which is associated with contraction, the generation of heat and the production of electrical changes. Thus, regarded as a machine, striated muscle is comparable to an internal-combustion engine, the fuel of which not only provides the energy but also directly drives the mechanism.

Let us now turn to our laboratory knowledge of fatigue in the nervous system. Nerve fibres are not

appreciably fatigable. The nervous impulse, as it travels along a nerve fibre, is really a succession of momentary discontinuous changes which are probably of a physical character, dependent on a movement of ions. When a certain degree of such movement has occurred, time is required before further movement is possible, and during that (extremely brief) interval the passage of the impulses is blocked. Thus the nervous impulse manifests itself as a series of electrical changes, separated by a series of instantaneous 'refractory periods' during which its passage is obstructed.

In the grey matter of the central nervous system, too, a refractory period (here of appreciable duration) is easily recognizable. Indeed for certain reflexes such a period is essential; for if, e.g., in the scratch reflex, the efferent or out-going impulses followed too rapidly one on the other, its rhythmic, clonic character would be converted into a continuous, tonic one. Hence a refractory phase, a state of block in or near the synapses of the nerve cells, regularly succeeds each scratching twitch; the stimuli failing to pass from the afferent to the efferent side if they exceed a certain rate.

Fatigue certainly exists in the central nervous system, in the sense of a diminished excitability consequent on previous excitement. This applies equally to inhibitory and to exciting central mechanisms. For inhibition involves activity, not less than excitation, and both inhibition and excitation wane after a certain use. [But how far such waning is due to fatigue or to adaptation is

quite unknown. For the excitatory and inhibitory mechanism are so closely integrated that there always exists a balance between them, tending, on disturbance of that balance, to a new poise – set or attitude – to an adaptation to a stimulus or environment rather than to a true fatigue to it. In the sphere of the senses we can easily distinguish between the fatigue which arises from the stimulation of the heat or cold spots of the skin and the adaptation which follows prolonged exposure to warmth or coolness. The after-effect of a stimulus producing fatigue is 'no response': but where, instead, adaptation has occurred, the after-effect is a 'contrast effect,' as the adaptation to one environment changes towards adaptation to another.]

We have experimental evidence that, whereas nerve fibres are virtually indefatigable, the end plate – the structure in which each nerve fibre terminates at the muscle fibre – is more readily 'fatigued' than the muscle fibre itself, blocking the transmission of the impulse from nerve to muscle at a time when the muscle fibre is still responsive to a stimulus applied to it directly.

Interesting experiments on muscular activity in the intact human organism have been conducted by means of the ergograph, an instrument ideally recording the voluntary contractions of a single muscle, e.g. a series of flexor movements at a single knuckle joint, and involving the lift of usually a relatively heavy weight. In

these conditions fatigue appears to be largely due to inhibitory nervous impulses ascending from the muscle to the central nervous system, and making it more and more difficult for impulses to descend to that muscle which would otherwise throw it into contraction. Some of these ascending impulses from the exercised muscle affect consciousness in the form of discomfort, pain or cramp; but others act purely reflexly, blocking the path of outgoing impulses and thus inhibiting voluntary movement. Hence when volition is powerless to evoke further ergographic records, they may still be obtained by stimuli applied on the skin surface to the motor nerve running within the limb to supply the muscle the contractions of which are being studied.

[Hence in ergographic (and in heavy muscular industrial) work, pain and discomfort are largely instrumental in inhibiting further activity. But these are protective only. If they be disregarded, or if such feelings become blunted, further activity is possible. Moreover, increased interest, excitement, the influence of emotion or suggestion, may, as is well known, either prevent fatigue from manifesting itself or evoke revival of muscular or mental activity.]

Normally the higher nervous levels exercise an inhibitory influence over the lower, maintaining a reserve of muscular power which may become manifest in fatigue and under the influence of certain drugs, say, of alcohol. Such loss of higher control and direc-

tion may therefore manifest itself temporarily in an increase in the amount of muscular work performed. Hence higher fatigue does not necessarily imply an immediate reduction in the amount of muscular work, although it involves all the consequences of lessened control – first, loss of that delicate co-ordination of movement, associated with the higher nervous levels, and secondly, extravagant expenditure of muscular energy. Hence, too, the outburst of energy revealed on release from factory confinement is no contra-indication of fatigue.

Laboratory experiments have shown the importance of rest pauses and of changes of posture in relation to recovery from the effects of muscular exercise, a far greater total amount of work being elicitable when more frequent rests and changes of posture are introduced.

Let us turn now to consider laboratory investigations into mental fatigue. Much of this research has consisted in the study of curves of output recorded minute by minute, or five minutes by five minutes, during an hour or more's mental work. The work has been generally of a simple uniform character, e.g. adding pairs of figures, or erasing one or more prescribed letters throughout a printed text. Here, again, the value of rest pauses on subsequent output has been demonstrated, and attempts have been made to determine the most favourable length of rest pause for a

given period of mental work. But the chief value of such experiments has lain in the analysis of the work curve, which has brought to light the play not only of 'practice' and of 'fatigue' (not only, that is to say, of the acquisition of skill and of the loss of efficiency resulting from exercise), but of (*a*) 'incitement' and (*b*) 'settlement,' – the warming up of the subject to his work after he has been withdrawn from it, the recovery of lost rhythm and the neglect of distracting conditions – and of (*c*) 'spurts,' of which the most striking are the initial spurt when the subject starts fresh to his work, and the end spurt when he realizes that the end of his work is approaching. There also occur (*d*) temporary 'depressions' in efficiency due to various causes other than fatigue.

[Valuable as have been the results of these laboratory inquiries into muscular and mental fatigue, they have proved far from adequate in their practical application. For the conditions of laboratory experiment are widely removed from those of work-a-day life. Muscular fatigue in the factory cannot be isolated, as in the laboratory, from such influences as skill and intelligence which depend on the proper functioning of the higher levels of the central nervous system. The most unskilled labour is really skilled, in the sense that there are good and bad methods of carrying it out. Further, a worker's movements cannot be compared with the movements of the subject of an ergographic experiment, who lifts his finger repeatedly and rhyth-

mically with the utmost force and to its utmost extent until he can move it no longer. The worker knows better than to exhaust himself in a relatively brief period by employing his utmost energy; he regulates his output according to his feelings of fatigue present or anticipated – that is, according to the length of the period during which he knows that he has to work.

Thus it comes about that, whereas in laboratory research, owing to the removal of normal inhibitory influence, feelings of fatigue are not incompatible with a temporary increase of work, in everyday life such feelings are more closely correlated with lessened effort and diminished output. Moreover, even when no work is being done, the worker's efficiency has been shown to vary at different hours of the day, the efficiency curve during protracted rest being similar in form to that revealed by actual work throughout the day, but of course at a higher level.]

The adaptation of the worker to the length of the working day has been well demonstrated by observations on the effects of changes in the length of industrial working hours. An improvement in the rate of output almost invariably results from shortening the working day. But it does not, as a rule, occur immediately; or, at all events, it does not attain its maximal effect immediately. Weeks or even months may elapse before the full beneficial effect is reached of the reduction of

hours on rate of output (cf. Fig. 1). The output continues slowly to rise for a period varying apparently with the kind of work involved, and varying no doubt with the worker, until uniformity is again established.

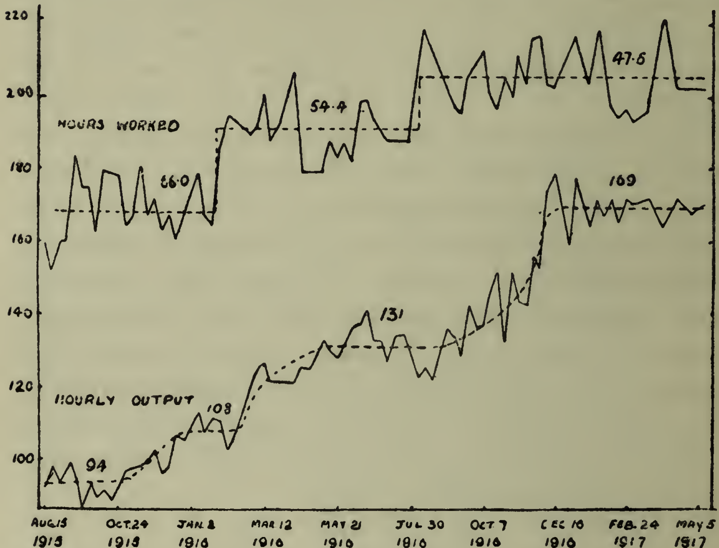

FIG. 1 (*after* H. M. Vernon).
OUTPUT OF WOMEN TURNING FUSE BODIES.
The dotted lines indicate roughly average results.

This can hardly bear any other interpretation than that the worker consciously or unconsciously adapts himself to the length of his day's work or of his work spell or shift. Hence, when that length is suddenly shortened, some considerable time is needed, during which he changes his rate of output, before he can

adapt himself completely to the new conditions of work. No doubt a number of other factors determines this change in rate of output. For example, the worker's output is consciously or unconsciously influenced by that of his fellows and by the tradition of the factory. But, apart from such complicating factors, the broad conclusion we are justified in reaching is that more or less unconsciously the industrial worker protects himself against fatigue by regulating his rate of output according to the length of his working spell or day. Such behaviour may lead to the setting up within the factory of an artificially uniform level of output throughout the course of the working day, i.e. to a habitual flat work curve, which may suddenly give place, in the unconsciously stimulating presence of an investigator, to a higher curve marked by a surprising initial rise and terminal fall – the result of unconscious and unmaintainable spurt.

It is interesting to observe that whereas adaptation to shortened spells of work is slow, adaptation to lengthened spells may be quick. Thus in the case of mill-men engaged in the tinplate industry, while it took 8–10 weeks to reach equilibrium at the higher rate of output after a change from an 8-hour to a 6-hour shift, on reversion to the 8-hour shift the output fell at once approximately to its previous level without any appreciable period of adaptation.

[The industrial worker, therefore, unlike the ergographic experimenter, does not continually put forth

his utmost power. He differs from him further in the fact that he is not always using the same joint or the same muscle. He may vary his posture as he begins to feel discomfort, changing the poise of his muscles or now using one set of muscles, now using another, for the same work, so that the previously used poise or set regains its freshness. Moreover, he is not contracting his muscles against so heavy a weight that in a relatively small number of lifts it is likely to produce complete impotence to execute further contractions. Nor under industrial conditions is the weight lifted a constant one, as in the ergographic experiment, where the fatigue manifested is fatigue to a definite weight. The ergogram is an expression of fatigue to narrowly restricted conditions. For if, when the ergogram has revealed total impotence, the weight lifted be slightly reduced, a fresh ergogram is immediately obtainable.

Similar objections may be urged in the case of laboratory experiments in mental work, where, again, the subject is working his very hardest for a relatively short period of time and the work performed is of the most uniform monotonous character, so uniform, indeed, that after a little practice, it may be carried on quite unconsciously. In so far as monotonous work in industry can be regarded as mental work, the laboratory experiments are to that extent comparable with the monotonous conditions of industrial life, if only it could be supposed that the worker is throughout working his hardest. But they are clearly incapable of

throwing much light on fatigue in work which demands the continual conscious exercise of intelligence and of adaptation, e.g., to variations in hours or to variations in difficulty or interest, of work.

Acts of muscular contraction, and probably acts of apprehension, acts of decision, and the like, may be regarded as explosive acts, fired off much as a heat spot fires off, so to speak, its sensation, and then requiring rest for recovery. But these acts, involving apparently the consumption of substance intracellularly laid down for outbursts of relatively intense, spasmodic activity, occur in a setting of 'tone,' 'posture,' and 'attitude,' perhaps much as the heat and cold sensations appear to occur in a setting of sensibility to warmth and coolness. Voluntary muscular contractions and conscious acts are of an intenser, more momentary character, readily susceptible of fatigue, whereas muscular tone and posture and mental attitudes are of a milder, more prolonged character, more resistant to fatigue. We can endure the light of a northern summer for hours without fatigue: adaptation appears to enter in place of fatigue. We can maintain a given posture likewise for a prolonged period: adaptation again enters, co-ordinating activity within pairs of antagonistic muscles. It is this process of adaptation, the maintenance of poise between antagonistic processes, which finally tires.]

In mental work it is the ability to preserve the right poise or attitude that finally tires, further mental work

becoming disorderly and useless. When we are engaged on a given piece of mental work – let us include even the repeated addition of pairs of figures and skilled muscular work, for these involve mental, though it be unconscious, work –, all conflicting nervous impulses must be inhibited, other distracting ideas and other muscular movements must be suppressed in so far as they are incompatible with the work we have on hand. Such inhibition in itself involves work. There is no adequate physiological evidence to support the view that inhibition is merely the result of the drainage of energy into other channels which are simultaneously active. The suppression of conflicting 'complexes' in psycho-neurotic conditions affords an adequate example of how active a process inhibition is. Work is done not less in inhibiting one process than in evoking another. To block any process is as strenuous as to unblock another; a poison (e.g. the toxin of tetanus) may easily convert an inhibitory into an exciting stimulus.

But this inhibition of incompatible attitudes, though it may last a long time, cannot continue for ever. It becomes more difficult, partly perhaps through inhibitory nervous blocking, partly because the hitherto inhibited or repressed attitudes and acts gain in strength and finally insist on manifesting themselves by bursting through the restraint imposed upon them, like the waves in an incoming tide that beat before a barricade on the sea shore.

We thus gain some idea of the place of boredom in our conception of fatigue. A favourable attitude of attention is facilitated so long as the effect of interest is present, the work remaining intrinsically and spontaneously attractive. Later, volitional acts of attention have to be employed to maintain this attitude; and as these become more difficult and more ineffective, the feeling of interest gives place to one of increasing boredom.

Serious fatigue of acts of attention is saved by the inhibition associated with the increasing boredom which now sets in. But if failure of interest be allowed to increase still further by further voluntary attention, worry and anxiety result. Conflicting ideas, hitherto repressed because of their incompatible or undesirable emotional concomitants, break loose from inhibition, causing anxious moods, disorderly unreasoned fears, etc., to colour or to intrude into consciousness. Such seems to be the relation between fatigue and the psycho-neuroses. We must also remember that worry and anxiety are not only encouraged by, but themselves encourage fatigue and inefficiency. Hence domestic troubles constitute the most frequent cause of occasiona lapses in the quantity and quality of the worker's output.

Fatigue of voluntary acts of attention appears to be of a general character; it diminishes the ability of the self to attend in whatever direction. The waning of interest, on the other hand, weakens the attitude of attention primarily in one specific pose, one specific

'constellation.' The effect of monotony and boredom is therefore at first local, not general; another field of attention may be readily and successfully adopted. In the one case the fatigue is mainly a fatigue of action: in the other it is rather a fatigue of setting or direction.

[It is naturally the most delicate, latest acquired and highest functions that suffer most in mental 'fatigue.' In the work of adding pairs of figures, it is not so much the speed or accuracy of the reaction to the presentation of, say, 2 + 1 that becomes impaired, as the ability fully to attend to and to apprehend the meaning of this presentation. Semi-automatic acts, such as simple reaction times, are poor criteria of fatigue. What suffers is mainly the ability to preserve the proper attitude.]

Routine work is not necessarily monotonous. Monotony is to be judged subjectively not objectively. An occupation which is found monotonous by one person may not prove so to another. Generally speaking, the more intelligent the worker, the more irksome becomes routine work, and the more difficult becomes the maintenance of the required attitude, because of the demands of his intellectual processes for more varied occupation. An excellent illustration of this is afforded by a recent laboratory experiment where four unemployed work girls were engaged in the daily repetitive work of cross-stitching throughout two months. Of these four girls, two had been rated by an intelligence test as highly intelligent, the third

showed average intelligence, and the fourth was distinctly below average in intelligence. Each of the first two girls showed distinct signs of boredom in the work; the one was restless and yawned, seizing every opportunity for change of posture and engaging far more often than the others in conversation, while the other confessed that she found the work 'very tedious and would not like to do it regularly.' These two most intelligent girls, although capable of reaching a high output from time to time, proved unable to maintain it. The worker who was rated third in intelligence did by far the best work, 12 per cent. and 16 per cent. respectively more than the two girls who were rated highest in intelligence. She declared at the end of the experiment that so far from suffering monotony in consequence of the repetitive work, she had rather liked it. Her regularity of output, too, was far greater than that of any of the other girls, 14 per cent. and 25 per cent. greater than the two most intelligent, and 22 per cent. greater than the least intelligent. The least intelligent girl showed considerable improvement with practice but made a very bad start, and appeared to be hampered by clumsiness, holding the needle with difficulty, and picking it up with difficulty from the floor on to which she frequently dropped it. She offered no objection to the repetitive work, but complained of the occasional conversation of the other girls.

The practical outcome of this experiment is that,

while monotonous work requires an appropriate degree of intelligence, it suffers appreciably if too great intelligence be brought to bear on it. Such ill effects may be safeguarded, as we shall see, by rest pauses and by changes of work. They may also be prevented by recourse to pleasant phantasy (day dreaming), and in certain circumstances, especially when the work is rhythmical, by refuge in song. Interest – whether immediate or remote, whether innate or acquired – is essential for successful occupation. Even acts which have become habitual, for which no mental effort is needed, cannot be performed for long, if all interest is lacking, whatever its direction, whether connected with the work or not.

In some laboratory experiments on the effects of varying work, carried out on three young adults during two daily spells of 2½ hours each, lasting over six weeks, the output increased by amounts varying from 2·4 to 24·2 per cent., and the errors decreased by amounts varying from 9·2 to 55·1 per cent. (according to the subject and the work), when the nature of the work was changed at about 50-minute intervals. The work was of three kinds, adding in the head sets of 5 digits, adding by means of a comptometer columns of 10 digits, and pulling every half-minute against a powerful spring balance with the right and left hands alternately. During three of every four days, one or other of the three tests was worked continuously. On the fourth day each spell was divided into three periods of 50

minutes, and the three tests were consecutively given during these three periods.

On the other hand, too many changes of work must obviously have a deleterious effect on output. In a manufacturing chemist's works, an increase of from 17 to 20 per cent. in the wages earned occurred when the operative was changing approximately every half-hour from one process to another, instead of, as before, carrying out from 100 to 250 different changes of process in the course of the day, giving an average duration of from 2 to 5 minutes for each process.

Closely allied to preservation of the right attitude and posture is preservation of the optimal rhythm and of the successful co-ordination of the various successive movements that make up an operation. Just as the members of a boating eight become 'ragged' in fatigue, using useless energy with relatively useless results, so the tired worker is apt to 'fall to pieces,' and his rhythm and skill suffer. This has been strikingly revealed in a study of the operation of 'roughing,' i.e. removing scratches and imperfections from spoons and forks, which are pressed for this purpose against a rotating wooden leather-covered wheel. A recording wattmeter was introduced to record the number and duration of the rougher's strokes, the pauses between the strokes, and the pressure of the strokes against the wheel, at different hours throughout the day. It was found (cf. Fig. 2) that the number of strokes per spoon,

the duration of those strokes, and the pressure with which the strokes were applied increased towards the end of the spell, when output was actually diminishing, and when fatigue might be supposed to be present. That is to say, in the investigator's words, the tired

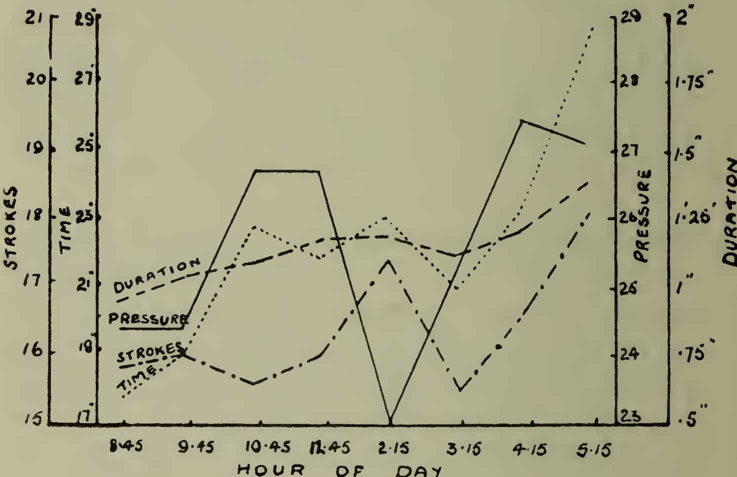

FIG. 2 (*after* Farmer and Brooke).

worker is 'not only working slower than when she is fresh, but is expending her energy extravagantly.' The number of strokes per spoon remained nearly constant during the morning; this was a fair indication of the maintenance of a steady rhythm. It was during the afternoon, especially towards the end, that the greatest variations occurred.

Just as, when interest fails, constant volitional efforts

have to be employed to maintain the requisite mental attitude, so when the natural rhythm fails through fatigue, conscious efforts have to be invoked to carry on the work (cf. pages 49–51). It is in this sense that rhythm is to be allied with muscular posture and mental attitude. All three can be prolonged for some considerable time before fatigue sets in. All three may be regarded as a nutrient matrix in which muscular and mental acts are set, the setting differing in temporal and spatial characters. All three require for their maintenance a directive activity which ultimately tires, – an activity of the nature of which we know no more than we know of that more general directive activity distinguishing animate from inanimate nature.

Fatigue, in the sense of a diminution of efficiency owing to prolonged exercise, is of course a normal and healthy result of all work; it can only be considered serious and abnormal when, after the rest which follows any given spell of work, it is not, in general, wholly dissipated. For then, spell by spell, day by day, the fatigue effects accumulate, and sooner or later the time must arrive when healthy fatigue is replaced by pathological exhaustion.

Taking the daily industrial work curve and comparing it throughout the week, sometimes we find evidence of such accumulation of fatigue, but in general it is dissipated by the week-end rest. The well-known

'Monday effect' is due to the loss of incitement and settlement (cf. page 44) caused by the week-end rest.

The amount of fatigue during the week varies with the skill of the worker. In the boot and shoe industry, e.g., the most expert operative's record was found to rise throughout the week, whereas the poorer worker's might begin to fall from Wednesday or even earlier onwards (cf. Fig. 3).

The influence of fatigue may be masked by spurts, or exceptional circumstances may interfere with its usual course (cf. page 44). Thus in some silk-weaving mills the best output occurs between Thursday morning and Friday noon, which is the 'making-up time' for calculating the wages to be paid on the week's work. The approach of an annual holiday, when the maximal piece-rate earnings are coveted, may lead to a similar spurt.

During the recent war the attention of the Health of Munition Workers Committee was directed to the proper length and distribution of periods of work and rest. There were times when munition workers in Great Britain worked nominally for 74½ (actually for about 66) hours a week. In one case, for example, 63½ hours were actually worked by women engaged in the moderately heavy work of turning fuse bodies. When their weekly hours of actual work were reduced from 63½ to 47½, their total weekly ouput rose by 13 per cent. An even greater increase in weekly output, an increase

of 19 per cent., followed the reduction of hours actually worked from 58·2 to 50·4 per week in the

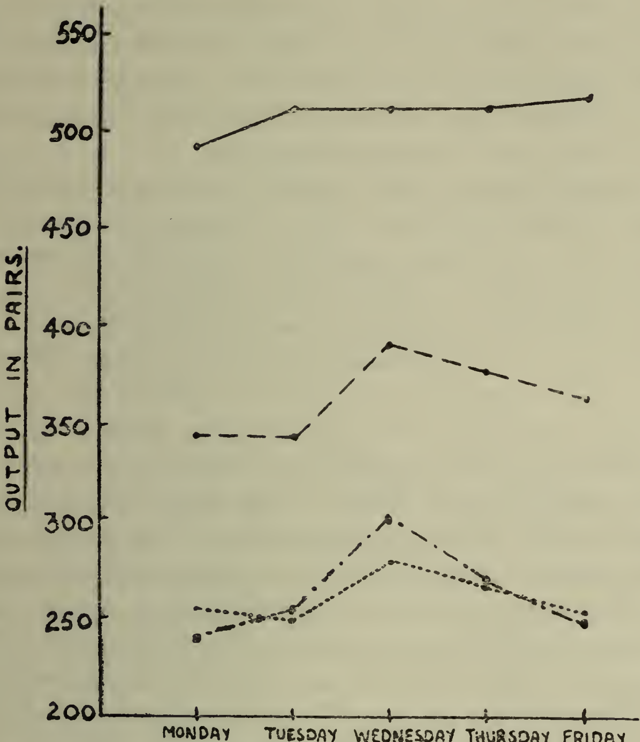

FIG. 3 (*after* Loveday and Munro).
AVERAGE DAILY OUTPUT OF FOUR BOTTOM SCOURERS.

case of men engaged in the heavier work of sizing fuse bodies. Not only was the output thus increased,

but a reduction in the amount of lost time through sickness, slackness, etc., also resulted. Thus in a shell factory the time lost fell from 11·8 to 6 per cent. after the hours of work had been reduced from 63¼ to 54 per week; while later in the iron and steel industry a reduction of the hours of work from 53 to 48 per week was followed by a reduction in lost time from 2·46 to 0·46 per cent. of the working hours.

But although the total weekly hours now worked in Great Britain do not generally endanger serious fatigue, we are nevertheless confronted with the important problem of the best distribution of those hours so as to secure the *maximal efficiency* (which includes the maximal health and contentment) of the worker. During the war a comparison was made between the output during 12-hour and 8-hour shifts among women workers who were engaged in cutting off the ends of the roughly forged shells. It was found that that part of the work which was dependent on the worker and independent of machinery, and which was performed in 100 minutes of the long-shift system, was accomplished in 80½ minutes when the short-shift system was adopted. This means a 19·5 per cent. improvement.

More recently the output records of four factories in the tinplate industry have been studied. The hourly output during 4-hour shifts was found to be 11·5 per cent. greater than when 8-hour shifts were worked. Under the shorter-shift system the output no longer showed the serious fall at the end of each day, which

had occurred in the longer-shift system. The amount of lost time was also less.

In certain glass works it has been found that the hourly output increased by about 10 per cent. when 8-hour shifts were substituted for 10-hour shifts. There was also an appreciable reduction in spoilt work and decrease in lost time when the shorter shifts were introduced. The increase in rate of output in the 8-hour shift was not in itself large enough to make the output equal to that in the 10-hour shift, but as the 8-hour shifts allowed of a twenty-four hours' use of the plant, the total daily output was higher than when the 10-hour shifts were employed, which involved only a twenty-hour use of the plant daily.

There can be no doubt, as we shall presently have occasion to re-insist, that the optimal length of the working shift, spell, day or week, must vary with the character of the work. No doubt it also varies with the make-up of the worker. But legislation and practice are seldom concerned with individual differences. These must sink before the welfare of the majority or the average. In certain occupations evidence has been brought forward to prove that the greatest hourly rate of output generally occurs during a 40-hour working week, and that it diminishes not only when the weekly hours worked are more, but also when they are less than this. Indeed short time is apt to prove a highly extravagant remedy against unemployment. Regarded

solely from the standpoint of the engaged worker's efficiency, it would appear more economical to keep half the workers at their normal hours of work, and to discharge the remainder, than to retain all the workers on half-time work. For the loss of incitement and settlement, inseparable from the longer intervals of rest under growing short-time conditions, diminishes the worker's rate of output. Moreover, as short time increases, he also tends to spread out his work so as to avoid still more short time. And if within a factory or shop some are paid by day rate, while others are paid by piece rate, the latter have actually been known, in a spirit of self-sacrifice and class loyalty, to spread out their work so that the former may not suffer by further curtailment of the time worked.

Let us now consider the effects of introducing a rest pause into a long, continuous spell of work. During such a pause incitement and settlement are lost, but so are boredom and fatigue, while the tendency to spurt is increased. 'Practice,' in its technical sense of acquired skill as a disposition, is not lost in pauses of a few minutes' duration. The most favourable length of rest pause and the most favourable point of its introduction can only be determined by careful expert analysis of the work curve. As laboratory research has shown, they vary with the worker, with the nature of his work, and with the duration of its spell. In a boot and shoe factory it was desired to increase the output

without adding new machinery. This was effected by allotting to each double press three, instead of the usual two, girls; each of the three working for forty minutes in each hour, and resting the remaining twenty minutes. An increase of output was obtained in the six presses worked, amounting to 45, 43, 59, 39, 43 and 75 per cent. respectively, the average increase of output for the six presses thus being over 44 per cent. The presses showing the highest increase were those worked by the least skilled operatives, in whom fatigue was doubtless most prevalent. Lost time and sickness were diminished, and a spare girl was always at hand in emergency to take the place of an absent member of the team.

Save in exceptional circumstances, however, the introduction of such lengthy periods of rest must prove impossible. On the other hand, the value of shorter rest pauses has been repeatedly demonstrated. But here again, as in the case of shortening hours of work, we have evidence that several months may be needed before the full effect of rest pauses may be reached. In an experiment on girls making bicycle chains, this needed six months; in one on labelling it took ten weeks. In the boot and shoe factory into which rest pauses were introduced (see above), the average output for one press, which before their introduction was 132, reached 171 during the first twelve weeks after the change, but rose to 183 during the next eleven weeks.

Here, again, it is on the slowest workers that rest pauses produce their maximal effect. When girls engaged on labelling were divided into three groups according to their speed of work, a ten minutes' rest effected an improvement of 8 per cent. in the quickest third, one of 17 per cent. in the slowest third, and one of 13 per cent. in the middle third.

There can be no doubt that in by far the majority of industrial operations, – in heavy muscular work, in work involving mental strain, and in light repetitive and monotonous work, – the efficiency of a spell of work which exceeds four hours can be improved if divided into two halves separated by a few minutes' pause. Unorganized pauses, taken surreptitiously or due to irritating waits for material, are of little avail or are even harmful. Again and again, workers have testified to their appreciation of an organized, general rest interval. Their boredom and fatigue are relieved; their unpleasant phantasies (if present) are removed. The work curve is not only raised in *height* but is also improved in *form*.

In the following instance obtained from sweet-packing, before the rest pause was introduced, the work-curve (see Fig. 4), averaged from a number of workers and showing the output for each half-hour throughout the day, is seen to rise until 9.30 a.m., remaining at the same level until 11 a.m., then declining, next rising from 12 to 12.30, probably through the influence of end-spurt, and finally falling slightly until 1 p.m., when

there is an hour's break for dinner. After the introduction of a rest pause of seven minutes at 11 a.m. not only is the curve generally at a higher level, but the level is much more uniform than in the previous curve, suggestive of a lessened call on excessive voluntary effort, and of more orderly, rhythmical methods of work. In the afternoon work curve, after the rest pause

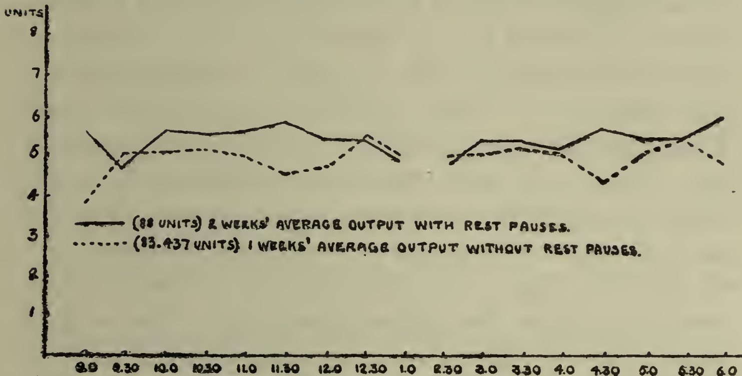

FIG. 4 (*after* Farmer and Bevington).

The output during the 23 minutes of the two half-hours into which a pause was introduced has been here raised to its calculated value if all 30 minutes had been spent at the work.

had been introduced (at 4 p.m.), the curve remains high and rises even up to six o'clock, the end of the day's work, whereas before the introduction of the rest pause it fell during the last half-hour. Without the rest pause at 4 p.m., the work curve is seen to fall sharply from 4 to 4.30; but after the seven minutes' rest has been introduced at 4 p.m., the work done during the remaining twenty-three minutes of the half-hour actually

exceeds that done in the same half-hour when no rest pause is interpolated. Despite a 3 per cent. reduction in total working hours due to the pause, a more than 5 per cent. increase in output, with less fatigue to the worker, resulted. The workers greatly appreciated the pause.

In another experiment an increase of over 14 per cent. in output was obtained by the introduction of a fifteen minutes' interval in the morning and the afternoon, which the workers, also engaged in sweet-packing, spent mainly in a *change of work*, not merely in rest. They spent the pause mainly in collecting materials, a task which had been previously carried out partly during the first fifteen minutes of each morning's work, partly distributed irregularly throughout the remainder of the day. They rested if they had collected their materials before the end of the pause. The output curve (Fig. 5) shows an enormous improvement in form as well as in height, both before and after the pause. The workers were unanimous in their approval of the change. The advantage, so far as the effects of incitement are concerned, of starting the work of packing in the morning with materials already collected, is obvious. This experiment raises the question as to how the rest period should best be filled. But our information on this point is not sufficient to warrant any definite answer, beyond stressing the need for a change of posture during rest.

[That the good effects of a rest pause may be to im-

prove output not only after but also before the pause is likewise indicated by the following data obtained in a laboratory experiment which consisted in adding series of five digits during morning and afternoon spells

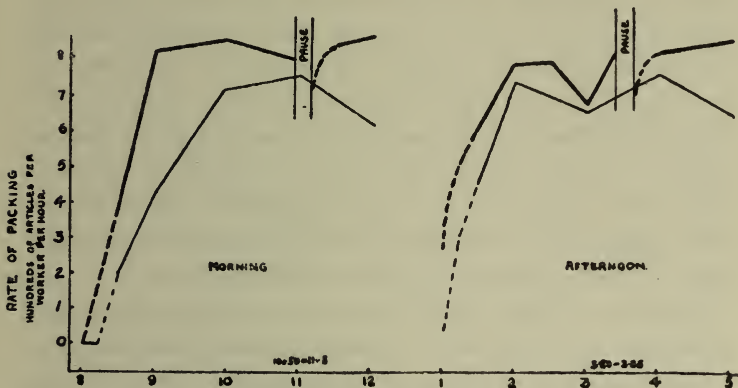

FIG. 5 (*after* Miles and Skilbeck).
The heavier line shows the output after the pauses of change of work had been introduced.

of work. The percentage increases of output owing to the rest pause were

	Morning.	Afternoon.
Before the pause	12·1	19·8
After the pause	20·5	24·1

A well-shaped work curve should not show too many irregularities throughout the day, for these indicate the excessive play of voluntary effort and effective influences and the inadequate help from habit and rhythm. Irregularities, initial rises and final falls there

must always be; an absolutely flat curve is unobtainable. Short end spurts may or may not be present, but they are so variable in occurrence, that they cannot in general be considered as characteristic of a good or bad form of work curve. The curve should not decline too greatly near the end of the spell or day's work, for this indicates excessive fatigue. Nor should it show too prolonged or too high a rise towards the end, for this signifies either that the worker has been unduly 'saving himself' in the earlier hours of the spell or that the work is so monotonous and uncongenial that the increasing previous inhibition is only removed by awareness of the approaching end of the spell.]

In various ways study of the work curve may reveal artificial 'stereotyping' or restriction of output. The average output of the department may show surprising constancy from day to day; the work curves of different workers may show striking similarity: the curves throughout the day may be unusually uniform or show an unusual rise towards the end of the day, so as to reach the stereotyped total day's output.

It is also possible to draw certain conclusions from changes in shape and level of the work curve that may result from changes in working conditions. In the first place, the curve may remain of the same shape but reach a higher level. This signifies that a greater output has been obtained under the new conditions with the same amount of effort and with the same fatigue effect of the day's work. Secondly, the curve may con-

tinue practically on the same level but now be of a far better shape. We may then infer that the operation has been facilitated by the changed conditions, in the sense not that it can be performed with greater speed, but that the cumulative effects of its repetition are less fatiguing than in the original methods of working. Thirdly, the curve may be on a higher level but of a worse shape. Here we may assume that the increased output has resulted from a quicker and more fatiguing method of working, such as may be expected when methods of speeding up are introduced with little regard to the health of the worker. Lastly, the curve may be on a higher level and also of a better shape. When this occurs, we are no doubt justified in considering that it indicates speedier, easier, and less fatiguing methods of working, yielding a higher output with less fatigue to the worker, despite the fact that he is repeating the operation a larger number of times during the day.

It must be remembered that, under otherwise similar conditions, the ideal work curve cannot be realized in industrial practice for *every* worker and for *every* type of work. The work curves of certain individuals may indicate a 'nervy' or neurotic condition; showing occasional wide daily deviations from a more frequent mean, or now an unusually good, now an unusually poor output, and but rarely a fair mean, or an output rising towards the end of a spell and better in the afternoon than in the morning spell. Some individuals work

better in short stages and by spurts, others over longer periods and more uniformly. The rest pauses which increase the output of most workers will, as has actually been shown by research, reduce the output of others.

Moreover, some types of work are characterized by considerable muscular fatigue. In these the work curve must be expected to fall considerably towards the end of the morning's work, to show a fair recovery after the mid-day break, followed by a progressive, well-marked fall throughout the afternoon. On the other hand, operations requiring skill and dexterity would be expected to give a work curve rising slowly in the morning to a maximal peak, as the worker settles to his work, followed by a less obvious fall than in strenuous muscular work (the effects of adaptation preventing or outweighing those of fatigue), a less complete recovery after the mid-day break (owing to loss of adaptation), and a smaller decline towards the end of the afternoon. Again, the work curve of operations characterized by rhythmical movements may be expected to show a considerable increase during the morning as the worker settles down to his rhythm, after which the output is relatively well-maintained throughout the rest of the day provided that the hours of work be not excessive. All these expectations have been verified in actual inquiry conducted on behalf of the United States Public Health Department. The stability of output occurring in the case of rhythmical work is found to be still greater in machine work, a steady rise occurring up to

the third or fourth hour of the day, after which there is little variation in the rate of production. But, as might be expected, these curves vary in shape according as they were obtained from an 8-hour plant or a 10-hour plant, those from the latter showing a slower rise in the morning, and an earlier and greater fall throughout the afternoon.

[Attempts have been recently made to claim that a special form of curve is apt to appear in monotonous work, the worker coming fresh to it at the start of the spell, then becoming bored with it and finally looking eagerly to its termination as the end of the spell draws near. The curve of monotonous work, if this claim be substantiated, falls in the middle of the spell and is higher on either side of it, thus being absolutely inverse in shape to the 'normal' work curve which reaches its maximum not far from the middle of the spell of work.]

From what has been said in this chapter, the impossibility will have been already realized of defining industrial fatigue in a way which will warrant the application of any of the various tests that have from time to time been devised to measure it. These tests fall into two groups. The first group consists of brief tests of efficiency which are applied to the worker at different times of the day or week, and compared in regard to their results. Thus the average of two or three successive grips of the dynamometer is registered, first, say in the early morning, then at mid-day, next in the

early afternoon, and finally at the end of the day's work, and the difference or lack of difference between the strength of the worker's grip at different hours of the day has been held to indicate the presence or absence of industrial fatigue. Other simple tests have been employed in the same way – such as a few reaction times, keenness of sight or hearing the delicacy of discrimination between two near simultaneous touches of the skin, or the speed of learning, in order immediately and correctly to reproduce a short series of numbers or letters.

When it became obvious that the worker could simulate fatigue by intentionally doing worse at the tests in the course of their application, tests were introduced which were independent of voluntary control, such as involved a record of the pulse-rate or of the time the skin took to recover its colour after being blanched by momentary pressure. But another important complicating influence still remained – that of the feelings. The worker may be at one time annoyed or at another relieved by being interrupted in his work in order that these tests may be applied to him; in the early stages of their use he may be alarmed by the apparatus involved, or in later stages he may be bored by them. Such effective variations could not fail to obscure the revelation of industrial fatigue, even if – as was tacitly assumed – the tests were competent to reveal its presence and to measure its degree commensurately with their results.

The second group of tests are in themselves tests of fatigability. A relatively lengthy task is imposed – e.g. repeated flexion and extension of a single finger-joint engaged in lifting a weight until the joint can no longer be moved, the central dotting of successively presented small circles, the addition of pairs of numbers, the erasure of a prescribed letter in printed matter, say for an hour, a work curve being obtained, movement by movement, or minute by minute, which has been held to indicate the fatigability of the subject, the curves being compared at different times of the working day, week or season. Of these the dotting test seems to be the most valuable. In the others the influence of practice often proves a serious practical difficulty. Moreover, the problem of whether, and if so how far, fatigue at a given occupation is local or general has been too often overlooked. And the degree of correlation between industrial fatigue and the evidence of fatigue revealed by the tests is unknown and apparently unknowable.

Many of these tests, especially after experience sufficient to remove the complicating effects of practice, become so automatic and are carried out so unconsciously as to be incomparable with industrial conditions in which the work is more varied, requires the exercise of a certain skill and judgment, and is subject to variety and competition of alternative paths. Fatigue tests are necessarily of a very simple character, measured by quantity rather than by quality of output. In

view of all these difficulties, it is hardly surprising that the interpolation of these tests brought discredit on the early attempts to estimate industrial fatigue.

If we continue to use (and it is almost impossible to avoid using) the term 'fatigue' in industrial conditions, let us remember how complex is its character, how ignorant we are of its full nature, and how impossible it is in the intact organism to distinguish lower from higher fatigue and fatigue from inhibition, to separate the fatigue of explosive 'acts' from the fatigue of maintaining 'attitudes,' or to eliminate the effects of varying interest, of excitement, suggestion and the like. In industrial psychology, our hope lies rather in the study not of interpolated fatigue tests but of the curves of actual output, endeavouring to analyse the various influences at work and to observe, by the comparison of curves obtained under different conditions, how industrial efficiency may be improved. As our knowledge increases, the work curve may become as full of meaning to the industrial psychologist as the curve of the heart-beat, now studied by means of the electro-cardiograph, is becoming to the physician.

Under present-day conditions industrial fatigue is generally not to be reduced by shortening the hours of the day's work. It is to be combated rather by the avoidance of too long uninterrupted spells of work, by the introduction (after careful study of the work curve) of rest pauses, and of change of work and posture, by determination of the best movements of the worker,

by systematic training of the worker in these movements, by selection of the worker so that his occupation is adapted to his innate abilities, by the abolition of causes of needless resentment, irritation and worry, by the introduction of suitable incentives to work, and by the provision of a good physical environment in regard to illumination, temperature, humidity, ventilation, food, etc.

It will be convenient, therefore, to include in this chapter a brief mention of the important influence of the physical environment to which reference has just been made.

It has been shown that in the process of cotton weaving the use of good artificial light in place of daylight reduces output by 5 per cent., and that in the more delicate processes of silk and fine-linen weaving it reduces output by 10 and 11 per cent. respectively. The importance of illumination in mining has been already mentioned (page 23). Improvements in it have yielded from 10 to 15 per cent. increases in output. In a sweet factory the removal of certain workers to a better-lighted situation increased their output by 10 per cent. The problem of illumination which confronts the industrial psychologist is not merely one of physical intensity. The influence of undesirable glare, flicker and contrast have likewise to be studied.

In fine linen and in cotton weaving, it appears that owing to the discomfort and fatigue of the weavers, efficiency falls when the wet-bulb temperature rises

beyond about 73° F., despite the fact that a higher temperature and a higher degree of humidity are favourable from the point of view of their physical effects on the manufacture of the material.

The effects of temperature on output are sufficiently indicated by the data of seasonal variations obtained in the iron and steel industry and (cf. Fig. 6) in the glass industry. In many instances it has proved possible to increase the efficiency of the worker by protecting him from needless exposure to high temperature. The kata-thermometer has proved valuable in affording important indications of the degree of stagnation of air in a factory; with its aid standards of ventilation have been established, varying with the nature of the occupation.

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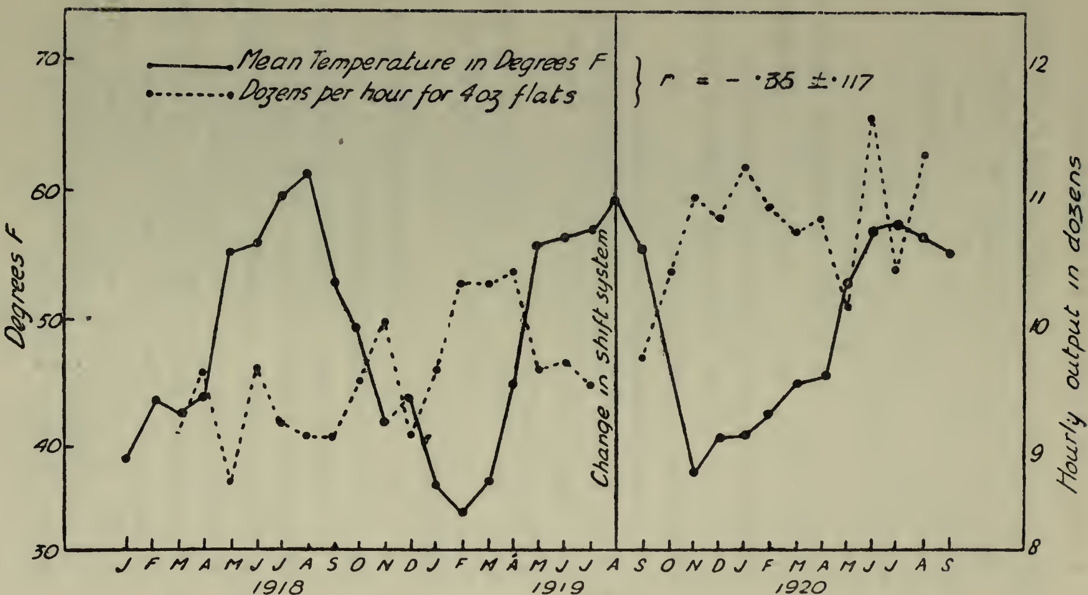

FIG. 6 (E. Farmer).

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Chapter 3

MOVEMENT STUDY

THE primary object of movement study in industrial psychology is to improve those movements of the worker that are necessary for the effective execution of a given operation, and to abolish those that are unnecessary. Movement study may be conveniently subdivided into 'gross' and 'minute.' Gross movement study deals with the larger movements and postures of the body and limbs involved in an industrial operation, including the arrangement and supply of material to the use of which such movements and postures are directed. Minute movement study, often known as 'motion study,' is concerned – in closer detail – with the finer, more delicate, movements; especially with the movements of the arms, hands and fingers, of the operative.

Movement study is intimately associated with time study – because often its value can only be expressed in terms of a comparison of the times taken to carry out an operation before and after the results of movement study have been applied.

Time study, too, may be conveniently subdivided into 'gross' and 'minute.' Many examples of gross time study have been given in the preceding chapter, where the rate of output has been timed under different conditions, e.g. at different hours of the day, on different days of the week, at different seasons of the year, with different lengths of spell, different conditions of illu-

mination, humidity, etc. Minute time study is conjoined with minute movement study in ascertaining the length of time required for the performance of each elementary movement or group of movements of which an industrial operation is composed, and in determining from the data thus obtained the proper length of time in which that operation should be completed.

It was pointed out in the preceding chapter that in its early days movement study was employed to discover 'the one best method of work,' whereupon all workers were to be trained in that method, regardless of their mental and bodily differences which might make that particular method unsuited to them.

In those early days, too, it was supposed that success could be attained by dividing an operation into a number of different parts, in observing and standardizing the movements of a certain operative who performs one of those parts in the quickest time, in observing and standardizing the movements of another operative who performs another of those parts in the quickest time, and so on; finally collecting and stereotyping the different parts thus studied into one whole which is thereupon to be forced on every worker as 'the one best way.' Let us see how the attitude of the industrial psychologist differs from that of the industrial engineer.

The psychologist insists that an organism is more than a sum of parts thrown together haphazard. The healthiest organs, obtained from a number of different people, would not, put together, form the most efficient

individual. Nor is the best mode of carrying out an industrial operation to be derived from a combination of more elementary movements selected from different individuals. Style is all-important. An organism is organized; an individual is indivisible. His parts are inter-related and integrated; and it is that very inter-relation and integration which distinguishes the organism and the individual, let us not say from a machine – for who would expect the best from a machine, with its parts thus thrown together, without previous adaptation? – but from a mere aggregate of parts, much as a chemical compound is distinguished from a chemical mixture.

Minute time study and movement study have also reacted viciously on one another owing to the belief that the speediest movements and the shortest movements must necessarily prove the most efficient and the least fatiguing. More recent investigations have demonstrated that this is far from being always the case. The quickest movements – and, still more obviously, the quickest rhythms of movement – may well be the most tiring in the end; and it has often turned out that longer, sweeping movements are less tiring than shorter ones, abruptly changing in direction.

Time study was at first chiefly employed to establish a standard of speed which workers were then expected to maintain. With this object Taylor selected first-rate workers, and by increased remuneration induced them to work as fast as possible while they were being timed.

He then made certain allowances for rests and unavoidable delays and for the abilities of the less expert workers, and thus established a standard speed of work.

Such procedure would now be regarded as unsound, – scientifically, sociologically and psychologically. It is unscientific, because obviously no accurate information is available upon which the amounts to be deducted for the allowances made can be based. It is anti-social, as it aims at excluding, as far as possible, the average workman. It is unpsychological, since it is a measure of rate of work obtained under abnormal conditions and in circumstances that cannot fail to arouse an undesirable mental atmosphere throughout the factory.

The mathematical advantages of fixing a standard rate of output are obvious, but against these we have to bear in mind the hourly, daily and seasonal variations in efficiency, to which attention was directed in the preceding chapter, and the effects of a standardized rate of output on the worker. To maintain a fixed output under different mental and bodily conditions is likely to mean that the operative has to work too strenuously at one period and too slackly at another. In times of indifferent health, his condition is made worse by failure or anxiety to attain the standard expected of him. In times of usually good health he may reasonably fear to show those who are set over him what he is now capable of.

If only the mental atmosphere in a factory be right, the workers will set their own standard of output; and

as the majority of mankind, when placed under just conditions, is honest and honourable, that standard will prove in the long run to be the most satisfactory.

If, in disregard of the afore-mentioned psychological pitfalls, efficiency experts introduce time study into a factory with the expectation that it will directly lead to improvement in output, they are likely to be disappointed in their efforts. Time study, however, has valuable uses. It may be advantageously employed for fixing piece rates, with which object the average and the indifferent workers must be timed as well as the ablest, and the effects of the workers' experience, age, sex, etc., must be ascertained and taken into account, if a fair result is to be reached. The inaccurate measurements hitherto made are responsible for the almost universal complaint in factories that some forms of piece work are far better or worse paid than others. For some work the piece rate has been fixed too liberally, in others the reverse. This may be unfairly utilized by the foremen in apportioning the best-paying kinds of work unduly to their favourite workers, and the worst-paying to those with whom they are on bad terms.

Time study can also be usefully employed to ascertain the times required to carry out the various parts of an operation, the relation of those times to one another, and their variation under different conditions. By the help of such information the processes under study may be greatly improved.

[Thus in a sweet factory the unproductive time spent

in emptying trays and in replacing full ones was reduced from 21 to 7·44 per cent. by increasing the size and number of the trays; and the output was increased by 1·31 lb. per hour by regularizing the supply of sugar, thus avoiding the irritating effects of the irregular pauses of waiting for the arrival of raw material.

In a cabinet factory, time study revealed that only about 38 per cent. of the time was spent on the cutting machines in productive labour, the remainder being mostly occupied in setting up, adjusting, and taking down cutters, arising from the varied work which the machines were required to perform. It also showed the frequent interruptions and changes in the men's work.

Time study has been usefully employed to show the mental effect of rejected and returned work upon output. In one instance it was found that the time taken to do the rejected work over again was increased in the case of three girls by 8·6 per cent., 17·5 per cent. and 18·5 per cent. respectively.]

We see, then, that time and movement study are no longer applied, by those who have been adequately trained in the principles of industrial psychology, with the ideal of speed primarily in view. To enforce speed tends to promote flurry, over-pressure and the appearance of needless movements. It is essential to lay initial stress on ease of movement; when once that has been attained, speed may be expected to look after itself.

But it has sometimes been said that speed of movement should be insisted on from the outset of training, this

view being based on the observation that an operation may be performed by different movements according as it is carried out slowly or rapidly. Gilbreth, for example, found that an expert, in demonstrating to him his methods of movement, employed quite different actions when he was asked to move more slowly. But this objection is easily remediable. It will be more conveniently considered when, later in this chapter, we come to deal with the training of the worker.

From observations on movement study, three classes of movement of the worker have been distinguished – (i) those strictly necessary for the work, (ii) those due to the worker's adaptation to rhythm of movement, (iii) those due to the worker's inexperience and to bad arrangements of material. The last must obviously be abolished by improved training of the worker and by study of improved arrangement of his material.

All who have studied workers at rhythmical repetitive work have observed how frequently they insert regular accessory movements which to the observer appear quite unnecessary for the action performed. Grosser movements of the body may be superadded which are obviously both fatiguing and needless, e.g. certain swaying movements of the body, which have been observed to persist during conversation after the rhythmical work has ceased. Some, at least, of these harmful accessory movements probably arise from bad habits early formed, due to a premature striving after

high speed and output. Many others, on the other hand, may turn out to be really helpful to the worker to whose 'style' they are peculiar, and should not be condemned as unnecessary until after adequate study.

If we bear in mind that ease of movement is our first desideratum, it should be our aim to inculcate a graceful rhythm of movement and as few movements as are consonant with efficiency. Our guiding principles will accordingly be based on the following considerations:

1. Successive movements should be so inter-related that one movement passes easily into the next, each ending in a position favourable for the beginning of the following movement. The sequence of movements should be so framed that little mental effort is needed to pass from one to another and that an easy rhythm can be established for the automatic performance of the various movements of which the operation is composed, so that the mind can more readily attend to the final aim or end of that operation instead of being distracted towards the successive initiation of the several movements which are involved therein.

2. As a corollary of this principle, it follows that a continuous curved movement is preferable to several sudden changes in direction of movement.

3. It also follows that the number of movements should be reduced as far as possible, so as to encourage a rhythmical method of working. For it is clear that the greater the number of different movements composing a repeated series, the more difficult it will be to group

them into a rhythmical whole. Conversely, encouragement of automatic rhythm rather than of volitional direction of the worker's movements will tend to reduce the number of the movements which he will adopt.

4. The simultaneous use of both hands should be encouraged whenever possible.

5. No more effort should be used than is absolutely necessary.

6. When a forcible stroke is required, the movements and the material of the worker must be so arranged that the stroke is delivered when, as far as is practicable, it has reached its greatest momentum.

The application of some of these principles to actual practice will be now illustrated.

In an investigation into the process of packing chocolates, the fatigue involved was found to be primarily mental, not physical. A very striking fall in output was revealed by the work curve during the last three hours of the afternoon. As a result of various timings 'it appeared that a considerable amount of effort was wasted by the workers in discriminating between the different chocolates and in endeavouring to overcome mental states of indecision by voluntary effort. This was caused by the somewhat haphazard method of arranging the chocolates necessitated by the type of bench with which the workers were supplied. A new type of bench was accordingly constructed which enabled the worker to arrange the chocolates in such a

way as to make her work depend rather upon rhythm than upon a series of voluntary decisions.' This resulted in an average increase of output, for the five packers tested, of over 35 per cent., timed over a period of four days, at the end of which, however, the adaptation of the workers to the new conditions was far from being complete, as was shown by the still daily increasing output. At the same time the time curve (Fig. 7) showed enormous improvement in form. There was a higher rise of output during the morning (shown by a greater fall in the time curve) and there was a steady maintenance of output during the afternoon, in place of the well-marked decline (shown by a greater rise in the curve) under previous conditions. Thus we have an illustration here of the improvement of the work curve both in height and shape. That is to say, owing to the replacement of much unnecessary hesitation by rhythmical movement, we have obtained greater output with less fatigue. The reduced fatigue of the workers was indicated by the fact that they spontaneously expressed their gratitude to the investigators because they went home feeling so much less tired at the end of the day, despite their 35 per cent. increase in output. This increase in output has been not only maintained but surpassed during the three years that have elapsed since the investigation.

[Similar results, involving an increase of over 43 per cent., 17 per cent., and 16·6 per cent. in output, were obtained in packing boxes of mixed confectionery,

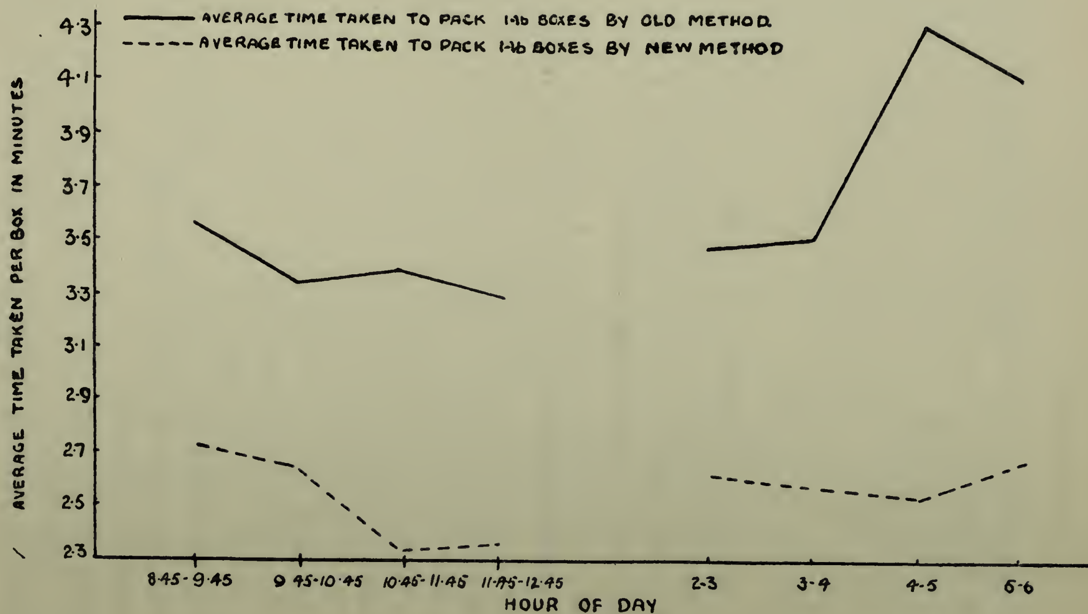
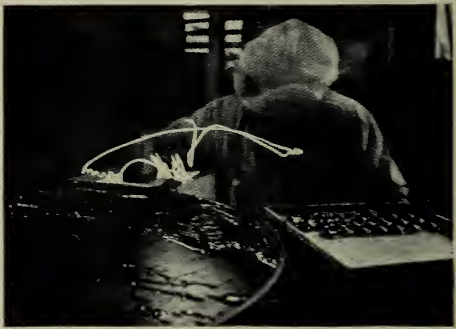


FIG. 7 (*after* Farmer and Eyre).

The many movements of a worker of long experience.

The investigator carrying out the essential movements.



The movements of a pupil after six months' training.

FIGS. 8–10 (E. Farmer).

[To face p. 91.

sweets, and bonbons respectively. By improved arrangement of material and redistribution of work, a diminution in labour cost of over 16 per cent. was obtained in cocoa-packing.

In the process of stalking raisins a new method involving the use of both hands was introduced, yielding an increased output of over 11 per cent. In almond-blanching the introduction of a simple desk, provided with side trays to receive the skins, increased the output by over 23 per cent. Increases of 10, 22, and 30 per cent. were obtained in coating chocolate biscuits, making meringues and packing biscuits respectively. In other departments of the same firm, the following increases were obtained by improved arrangement of material, by better equipment and by redistribution of work: roll-making, 32 per cent.; frame-cleaning, 14 per cent.; tin-cleaning, 36 per cent.; apple-crushing, 40 per cent.; cake-packing, 31 per cent.; labelling, 12 per cent.; bottle-packing, 18 per cent.]

One of the most important principles of movement study, as we have just seen, is to avoid a needless number of separate angular movements, instead combining them into a single uninterrupted sweeping circular movement. This principle was first studied by photographing the movements of an electric glowlamp attached to the worker's hand (cf. Figs. 8–10), in the chocolate-covering and sweet-dipping department of a confectionery factory. The same results as those just mentioned were obtained – an easier, rhythmical action

performed with far less effort and fatigue, and a considerably increased output. Indeed, so much easier seemed the newer method in the sweet factory that visitors, introduced first to a room in which the old methods were maintained and next to the room in which the new workers had been trained to the better methods, were convinced that the workers in the former room were working far harder, despite the fact that their output was considerably less; and several workers were reluctant to make use of these new methods because 'they felt that by so doing they would not be working as hard as they ought to.' By the introduction of such methods in the process of sweet-dipping, the worker being instructed to carry out a simple wider circular movement instead of stopping the arm twice and changing the direction of movement, an average increase of output amounting to 27·1 per cent. was obtained. The investigator describes how after three months' training in these principles in a better lighted and ventilated room provided with more suitable tables and trays, 'the workers were, on the average, producing 88 per cent. more than the workers of the same standing who were working on the old method in the original room. . . . Girls of 14 or 15 were earning a sum equivalent to that earned by girls of 18 in the old room.'

In a Lancashire coal mine, the miners' confidence was so completely obtained that they consented to be trained in the use of the pick by improved methods based on the same principles. The investigators spent

the first period of their work in familiarizing themselves with mining conditions and in getting to know the miners and to interest them in the investigation. The miners were carefully observed at their work, and their different methods were noted. The investigators themselves worked at the coal face. It was observed that energy was being needlessly spent in checking the upward stroke of the picking and in regaining speed for the downward stroke. The investigators trained the workers to wield the pick (whenever possible) in a continuous curved path. They also determined the varying optimal rate of rhythmically swinging the pick. This was found to depend on the hardness and nature of the material against which the pick was employed. The weight of the picks also received study, for many of them, owing to repeated sharpening, proved to weigh only 75 per cent. of their supposed weight. A considerable number of groups of miners were trained according to these methods. They were found after training to maintain the rhythm they had been taught, and they expressed themselves highly satisfied with the new method after the initial difficulties of adaptation had been overcome. Here are a few of their remarks: 'I can now use the weight of my body when picking coal.' 'The movement is easier.' 'I have more strength at the stroke and a better aim.' 'We are doing better, but cannot say why, except that we feel we are working more smoothly. We also feel more contented.' An increase in output of about 16 per cent. (cf. Fig. 11)

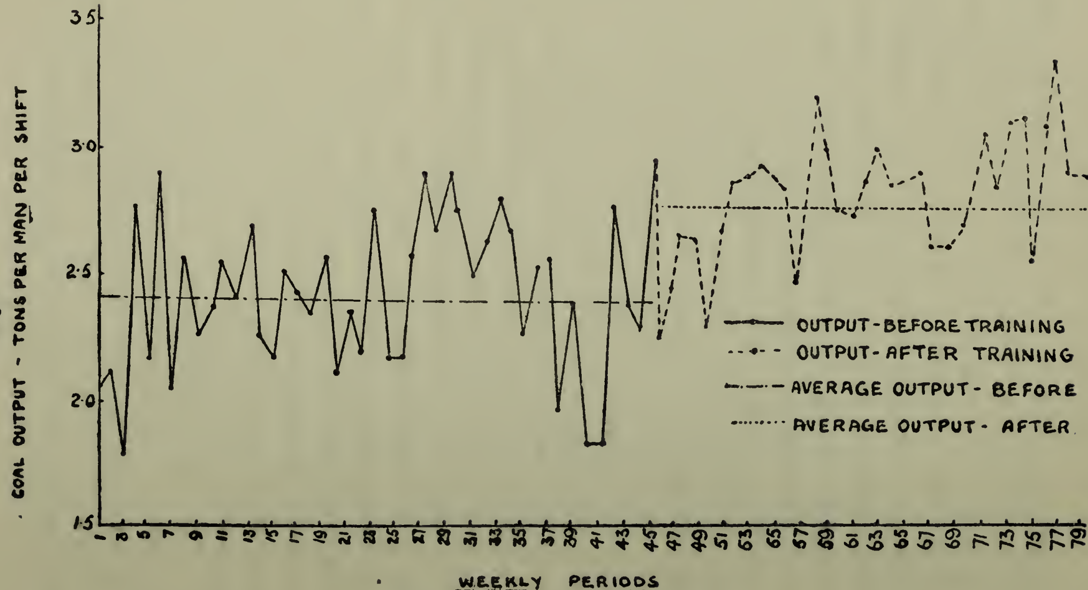


FIG. 11 (*after* Farmer, Adams and Stephenson).

appears to have resulted from these improved methods.

So far we have been dealing with the improvement in *quantity* of output as affected by movement study. Let us now turn to the effects of movement study on *quality* of output, that is to say on the amount of spoiled work, as exemplified either in defect of size, shape, or material, or in actual breakage. Spoilt work in general is attributable to various factors – the unsuitability of the worker to the particular work, his inexperience, his inattentiveness, the bad conditions under which the work is carried out – for which proper selection, proper training of the worker, and proper working conditions provide the obvious remedy. Other factors are revealed by constructing an hourly curve of the frequency of spoiled work. It may tend especially to occur at the beginning and towards the end of a spell of work, i.e. in the first place, before incitement and settlement have come into full play – while the operative is warming up and settling down to his work – and secondly, when he is becoming bored or tired and hence either is lacking in attention to his work or is endeavouring by a spurt to compensate for the effects of his fatigue. Over-pressure, indeed, is a potent cause of spoilt work; and so is emotional excitement, which is, of course, closely associated with over-pressure. Hence irritation or annoyance in general must be recognized as an important cause of increase of spoilt work.

Two interesting examples of spoilt work occurring in

different firms, both in the form of breakages, may be here mentioned. One firm, convinced that the breakages were due to sheer carelessness, had installed a scheme of penalties for breakages, and after six months discovered that the amount of breakages had actually increased. The other firm invited psychologically trained experts to conduct systematic investigations. These were first directed toward the discovery of the precise locality of the breakages, their absolute and relative frequency, and the modes and general causes of breakages. A two-hourly record of the different breakages in different localities was therefore obtained over eighteen days.

The investigators then began a close scrutiny of the causes of the breakages. Their attribution vaguely to 'carelessness' did not appear adequate. The main cause of the breakages was found to be attributable to excitement, annoyance, worry or irritation of the worker. Attention was therefore concentrated on eliminating, so far as possible, the existing periods of rush and the opportunities for irritation. At the same time, certain danger-points where breakages proved most frequent were carefully examined, and wherever possible, improved apparatus was installed, which would give scope for quicker and safer work. Two-hourly curves of spoiled work were constructed and compared, before and after these alterations (Fig. 12). The amount of breakages became consistently lower at all hours of the day, due doubtless largely to the

removal of many of the causes of irritation; and towards the end of the afternoon an enormous reduction of breakages occurred, which is doubtless attributable mainly to the lessening of fatigue effected by the

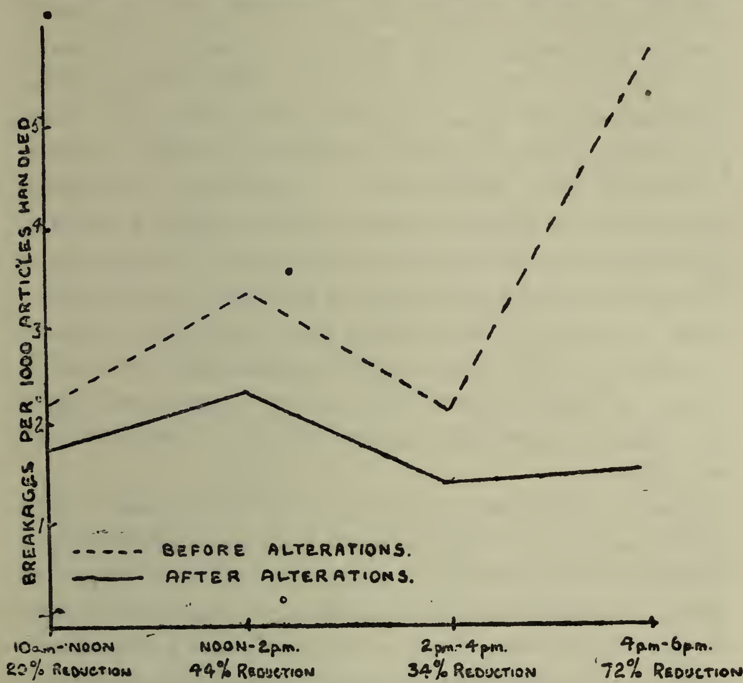


FIG. 12 (*after* Miles and Eyre).

improved apparatus introduced. On the one hand, the total reduction effected in breakages amounted to over 53 per cent. (in the case of certain articles it amounted to over 70 per cent.); on the other hand, the workers

were unanimous in their appreciation of the now greater smoothness and ease of their work.

Closely allied to the problem of breakages is that of accidents. We now know from statistical inquiry that accidents are far from being distributed uniformly among the workers, but that some workers are much more liable to them than others. We still await the detailed report of a psychological examination now proceeding of those persons who are specially prone to accidents. The characteristic is obviously a psychological one, and there is every likelihood that a series of psychological tests will be devised to differentiate, at all events extreme, instances of liability to and freedom from accidents. Those who are especially prone to accidents clearly need early detection and removal to places of safety where they are no longer a danger not only to themselves but often also to their fellow-workers.

Hourly frequency curves of accidents have been published, purporting to show a close correspondence between the number of accidents and the degree of fatigue at different hours of the day. But more recent inquiry has thrown doubt on the sufficiency of this conclusion. It is fairly obvious that in conditions of fatigue the worker is apt to be deficient in the care and caution necessary to prevent accidents. But carelessness and incaution arise not merely from fatigue directly, but also, and especially, from the excitement, irritation, worry and annoyance associated *inter alia* with the

effort to maintain speed in spite of fatigue. In industry such effort *may* or may *not* be made by the fatigued worker. Accidents thus have the same origin as may be attributed to much of spoiled work. On the one hand, they may arise from the wandering of attention to other fields of thought; and, on the other, from excitement, irritation, worry and annoyance, as well as (as in the case of spoiled work) from incompetence. Although worry, excitement and the like may accompany fatigue, they especially tend to occur during periods of rush and over-pressure; and it is at these times, often when output is at a maximum, that accidents are apt to be most frequent. At the end of the day, when fatigue is most marked, output may fall, alike by reason of the fatigue and because of a general lack of effort and because of the stoppage of machinery near the end of the day's work; for this reason accidents may become less frequent towards the end of the shift. On the other hand, we should expect to find accident frequency increased during spurts, wherever they occur, which are accompanied by temporary excitement, and in the erratic behaviour resulting from inexperience.

It is obvious that improvements in the movements of the worker and in the arrangements of his material can most readily show their effect when they are presented not to the worker of considerable experience whose methods have been fixed by long usage, but to the novice before he has had the opportunity of forming

bad habits and adopting inefficient methods of work. Who can doubt the importance of determining such undeniably wasteful methods of movement and of preventing the novice from falling into such bad habits of work? Yet how little provision is made for training the worker scientifically, i.e. systematically! In the case of sport, e.g. in riding, skating or golfing, few of us would dispense with the instruction of a professional expert. But in the case of industrial work, the novice has in by far the majority of cases to pick up his methods as best he can, perhaps learning from a worker of experience who may, nevertheless, have acquired bad habits of movement, or from one who, if he has acquired good ones, may be quite useless as an instructor.

The popular tendency has often been to decry training: 'the poet is born, not made.' Of what use is it to train the artist, the teacher, or – the worker? If he be really gifted to paint, to instruct – or to work, he will select his own methods; if he be not so gifted, no amount of training will make a success of him. It may further be objected – is it likely that an investigator who has been trained merely in the principles of psychology and physiology will be able to improve on industrial methods which have been evolved and perfected throughout many generations of workers?

But systematic training proves at least a short cut to what can only be learnt by trial and error after years of experience. Trial and error is the crudest and most wasteful form of gaining experience. While 'education'

aims at encouraging the youth's desirable instincts and at discouraging the undesirable, it is the object of 'instruction' to indicate to him the technique and the knowledge which are the social inheritance from his forbears. Moreover, few are so gifted that they can come to the front without any guide but their own experience. The great majority have some talent in a certain direction but not much, – certainly not enough to provide the driving force which enables the genius to overcome obstacles however great, and failures however dispiriting. Lastly, the average worker is enchained to tradition. An old method of work, good or indifferent, is preferred, even though the original conditions of work have been changed and the old method is no longer suited to the new conditions. Bad habits accidentally acquired are more easily continued than abandoned. Traditional methods of work have often been hit on by sheer accident, and it by no means follows that far better ones cannot be devised by the expert in psychology and physiology who, after adequate experience at the work under investigation, brings his previous scientific training and experience in cognate fields of industry to bear upon the problem (cf. page 36).

Alike in movement study, in training, and in considering the proper length and distribution of the periods of work and rest, we have to take into account, as best we can, the individual mental and physical differences of the workers. No industrial psychologist

would desire to force a worker to one method of work if the latter could demonstrate that another method was better suited to him. In vocational training, again, the mental differences of workers are so great that different methods of instruction must undoubtedly be employed in any one group of workers who are being trained. No doubt some may learn from a diagram, or a wire model (such as is provided by Gilbreth's chronocyclegraph) of the actions which are to be performed. But others are constitutionally incapable of profiting by such means; they need to see the movements *carried out*. Others profit readily by hearing or reading a *description* of those movements ; others again by repeatedly carrying out the movements *themselves* while they are looking at or hearing about them. Any good instructor of skating, golf, or of other similar games, if he have the proper psychological *flair*, will recognize the importance of these fundamental differences and adapt his methods of teaching accordingly. The problem of such important individual mental differences is the special concern of industrial psychology.

Let us take, as a first example, the improvements obtained in metal polishing by careful inquiry into the best movements and by employment of a specially intelligent polisher to train the slower and less efficient workers. These latter were engaged in polishing spoons and forks and it was found that some of the experienced workers took twice as long as others to do the same work. They would go over the same surface quite

needlessly time after time, regardless – and indeed ignorant – of the fact that overpolishing was wasted time, since the spoon was of standard roughness when it reached them and hence only demanded a standard number of polishing strokes.

The following are the results of the industrial psychologist's instruction of two workers, A and B, the first of three years', the second of nine years' experience.

		Before Instruction.	After Instruction.
Average time taken to polish a table-fork.	A	43 mins.	26 mins.
	B	44·75 mins.	33 mins.
Average number of strokes for three of the operations involved.	A	27	14
	B	21	16

Two very young, keen, and intelligent novices, C and D, who had spent ten days in the factory picking up their methods as best they could, received but one day's tuition in the improved method and gave the following results –

		Before Instruction.	After Instruction.
Average time taken to polish a table-fork	C	70·25 mins.	27·75 mins.
	D	81·50 „	31·50 „

Twelve girls with some previous experience in 'roughing,' i.e. removing scratches and imperfections from spoons and forks, were similarly trained, four at a time for a week. Compared with their wages for the

three weeks preceding this training, their average earnings for the first, second, and third week after training were 27, 26, and 36·5 per cent. higher. The average time taken by them to rough three dozens of dessert spoons was reduced from 126 to 89 minutes, and the number of strokes fell from 119 to 83.

Similar results followed an experiment in training workers to the packing of chocolates. The methods introduced involved the simultaneous use of both hands and the adoption of an easy rhythm of movement. Instruction cards were prepared and given to each of the trainees, over whom a suitable girl was placed as instructor. Twelve novices, of only moderate general ability, were trained for seven weeks, spending the first fortnight in a well-paid and easy line of packing half-pound boxes of a certain variety of chocolates which we will call X. During the following weeks there was a weekly change in the type of boxes and chocolates which they had to pack. At the end of the second, fourth, and sixth week a time test was given of packing four dozen half-pound boxes of X chocolates. The figures in the sixth week of training showed an average improvement of about 24 per cent. upon those obtained in the second week of training. Their average weekly wage during each week of their training was –

Week	1	2	3	4	5	6
Wage	9/4	11/8	11/7	12/5	14/4 (highly paid work)	13/5

While these twelve novices were being trained, other new girls were drafted into the packing-room. Their overlooker was, as usual, so occupied with other duties that she had to leave the actual instruction of these latter girls to those who examined their work. She took a keen interest in the new scheme of training and gave permission for her five best workers to be given the same time test as has just been described, in the fifth week of working. These results were then compared with the time test given to the five best of the twelve girls in their fourth week of training.

	Untrained Girls.	Trained Girls.
Folding sheets	22 mins.	22 mins.
Filling trays	62 ,,	47 ,,
Weighing	17 ,,	14 ,,
Packing boxes	115 ,,	90 ,,
Cording	29 ,,	20 ,,
Ribboning	31 ,,	20 ,,
Wrapping	48 ,,	43 ,,
Total	324 mins.	256 mins.

In other words, the girls who had been trained by the new method were 21 per cent. more efficient than those who had received no systematic course of instruction.

It is noteworthy that the time study involved throughout this investigation proved especially valuable in enabling the instructor at once to detect in which part of the operation a slow packer's defects lay.

In the course of the investigation, it also became clear that the expert worker is in general likely to prove a bad teacher owing to the extraordinary automaticity and rapidity of his (or her) movements. The expert is useful for demonstrating, but a teacher is needed to point out what is being done and to explain why it is being done. The expert often proves not to know what movements he is carrying out and, as Gilbreth long ago found, is apt to act differently when requested to move slowly. A teacher can safeguard the learner against this danger. This, then, is surely the solution of the difficulty which led Gilbreth to lay stress on sacrificing quality to speed of output during the instruction of a novice in the movements required for an industrial operation.

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Chapter 4

VOCATIONAL GUIDANCE AND SELECTION

BY 'vocational guidance' is meant the advice given to the applicant, based on systematic examination of his mental and bodily condition, as to the occupations for which he is fitted and unfitted. 'Vocational selection,' on the other hand, is the process of choosing by such examination those applicants who are best fitted for the existing vacancies in any one occupation. That is to say, vocational guidance aims at finding the best job for a particular worker, whereas in vocational selection we try to discover the best worker for a particular job. Vocational guidance rests on the assumption that of all occupations some are better suited than others to the mentality and physique of any one worker; vocational selection assumes that some workers are better fitted than others to any one job. None will deny the truth of these assumptions; the only question at issue is the best means of acting upon them.

Until relatively recent times, vocational guidance has been left almost wholly to the individual and his family. The young worker, choosing his life's work, may be influenced by his own interests and desires. He may be prompted by a love of adventure to go to sea, by a craving for admiration to go on the stage, or by ambition to rise in the social scale to take up office- instead of artisan-work. Or he may be subject to similar pressure on the part of his parents, e.g. to their desire that he shall follow his parent's occupation or

avail himself of some special influence expected of a relative or friend in a particular vocation.

The result is too often disastrous. Because a boy or girl has certain interests or desires in relation to a given occupation, it by no means necessarily follows that he will do well at it. Those interests or desires may be related only to a very insignificant aspect of his future work. For example, the love of adventure will not suffice to make a good seaman, nor will the desire for self-display necessarily produce a good dancer or actress. A strongly developed instinct of protection (and a predilection for the emotion of tenderness associated therewith) will not suffice for success in nursing, medicine or 'social work'; and far more than a strongly developed 'instinct of constructiveness' is necessary to make an efficient engineer. Such interests, moreover, may only be transient. And it must be realized that keen interests are by no means necessarily associated with an effective, practical expression of them. As regards the parent's opinions upon the best vocation for his child, these are notoriously unreliable; he is apt to be singularly blind to the most obvious signs, should they point to a career opposed to his own wishes.

It is needless to stress the immense importance of utilizing the best means at our disposal in vocational guidance and vocational selection. What a wastage of time, money and happiness arises from the 'round peg' trying to fit into the 'square hole,' and passing by trial

and error through a variety of different holes, until at length a hole is found which the peg fits! The employee becomes discontented, dispirited and diffident, while the employer wastes time and expense in engaging the employee and in training him to work at which he will never do well. Vocational unfitness is a prime cause of industrial unrest. Further, if a man is fitted to his work, not only is he happier and more efficient at it, but his health is better; both the *esprit de corps* and the sickness records of the factory are immensely improved. It has been truly said that the number of firms in Great Britain who keep a really reliable record of the actual costing of their manufactures is extremely small. But how much smaller is the number of those who know the amount of their annual labour turnover and endeavour to analyse and to remedy its various causes – one of the most potent of which is unsuitability for the job!

In Great Britain, of late years, school conferences and after-care committees have been formed for the purpose of improving vocational guidance; the teacher's previous knowledge of the child has been invoked at these conferences; and juvenile labour advisory and supervisory committees have been established expressly for adolescents up to the age of 18. But none of this work has been conducted in a really systematic, scientific fashion. The teachers' reports have not afforded sufficient information to prove generally helpful. Vocational guidance has been too exclusively based on a brief interview, and this has proved inadequate.

The interview has hitherto been likewise practically the sole basis of vocational selection; indeed too often the worker is engaged, even without a preliminary interview, at the call of some foreman. Let us suppose that a certain number of vacancies occur in a factory, and that a larger number of candidates apply for them. Recommendations from past employers or reports from the candidate's school may be taken into account, but selection and allotment to different occupations within the factory are commonly based on the results of a brief interview. Thereafter the engaged employee, if found unsuited for his work and undischarged, is wafted from one department to another, on the principle of trial and error, until he finds work at which he proves successful.

Let it be clearly recognized at the outset that neither in vocational guidance nor in vocational selection is the abolition of the interview here suggested. On the contrary, the interview supplies certain information which, at present at least, can be adequately obtained in no other way. It affords an excellent idea of the personality of the candidate, his bearing, address and speech, his honesty, loyalty, leadership, etc. But by systematic study of the future possibilities of the interview conducted under more scientific conditions, it is already proving capable of affording a far more reliable estimate than heretofore of these and other qualities. The interview can now be carried out with far clearer aims of the various factors which need to be observed.

Rating scales for their evaluation (cf. page 126) are being introduced, and still further improvements may be expected by adoption of some of the methods pursued by the psychiatrist in mental analysis.

But for successful guidance and selection we need more information than can be thus supplied – information that is only obtainable by more specialized methods of examination, and these must be added to the method of the interview. They involve a medical, a physiological and a psychological examination of the candidate, and are already being applied by some of the most progressive firms and other bodies in this country.

[In a rough way, of course, they have long been applied in the case of certain occupations. The soldier is examined for his eyesight, the sailor and the engine driver for his colour vision, a certain standard of physique is required by the services, and of health in certain civil occupations. But we need to go much further than this. A large number of tests are now available, by which we can arrive at a fairly accurate measure of the general intelligence, and of the special abilities of the applicant for vocational guidance or selection. And a large amount of information can be obtained, both from observation of the candidate's behaviour at the tests, and from questions put to the candidate by the examiner, as to other important qualities which are not, at present at least, capable of measurement or submissible to experiment.

For this and even more cogent reasons, many of the

tests must be applied, or at least their application must be supervised, by a properly trained person. The practice of entrusting colour-blindness tests to examiners untrained in the psychology and physiology of the subject has proved at times unsatisfactory. How much more so must it be when testing for other characters far more complex, more intricate and less susceptible of simple, direct measurement! In a rough way, general intelligence and the like can be determined by the untrained applying standardized tests to groups of subjects; but injustice may be done in individual exceptional cases. Would an engineer place any confidence in the results of a test of brake horse-power carried out by a psychologist or a physiologist? How much more unreliable must psychological and physiological tests prove, when carried out in a factory by an engineer! Yet this is what educational and industrial authorities are always demanding – a series of mental and physical tests which can be safely applied, without expert supervision, by those untrained in psychology and physiology.]

The systematic application of scientific tests to vocational selection has met with greater success than their application to vocational guidance. This is not difficult to account for. Vocational guidance is required at adolescence when the mental constitution of the individual is in a less stable, less settled state than later. The inquiry necessarily traverses a very wide field. It may not be possible, it is often undesirable, to give very

definite guidance; the adviser may only be able to state what classes of occupation the subject is fitted or unfitted for. It may be difficult to find a vacancy in the occupation for which the applicant is best fitted, or to convince him that that occupation is the one he should adopt – for if vocational guidance is to be successful, the applicant should be made to feel that he is himself finally choosing his vocation.

On the other hand, the opportunity for vocational selection often occurs not only in later adult life but also in the case of persons who have already adopted and had experience of some specific occupation. Hence it is possible to submit them to 'sample' (or 'trade') tests which will measure their efficiency at their actual work, or to 'analogous' tests which demand the exercise of abilities closely similar to those required for the actual work or for some part of it. In the case of adolescent applicants for vocational guidance, it is not practicable to give them 'sample' tests; for to some applicants these tests may be quite novel, whereas to others they may be more or less familiar. We must have recourse either to 'analogous' tests or to the third method of vocational testing, the method of 'analytic' tests, which depends on abstracting the various qualities required for success in a given occupation and on testing each of these qualities more or less separately. We shall describe, illustrate, and compare these three methods later.

[The more scientific development of vocational selec-

tion was greatly favoured by the recent war. In Great Britain tests were then devised and applied to select e.g. air-pilots, and hydrophone operators who were to be engaged in localizing the position of hostile submarines by a kind of telephone listening. The third method of vocational testing was here mainly followed – the analysis of, and the subsequent testing for the various qualities essential for success in these important occupations. For example, candidates for hydrophone work were tested for their appreciation and memory of the pitch and rhythm of sound, for accuracy of sound localization, for discrimination of slight changes of intensity, for ability to pick out a certain sound from a background of sounds, etc. It is noteworthy that when the first batch of men thus selected had been sent away to be trained, the report came back – 'they are the best lot we have yet had sent to us for training,' and that after the second batch had been received, it was reported – 'these are better still.']

Vocational selection tests are now being applied by a large number of firms throughout the world. In Germany, for instance, such tests are used by Krupp's, Zeiss, the Allgemeine Elektricitäts-Gesellschaft, Siemens and Halske, the Osram Company, the Berlin Tramcar Company, the German State Railways, the Post Office, etc. These concerns have installed psychological laboratories in which vocational tests are conducted. And the more progressive firms in Great Britain are rapidly following suit. Vocational selection

tests, devised by the National Institute of Industrial Psychology, are being successfully employed in Great Britain for engineers, weavers, embroiderers, dress-makers, packers, chocolate and biscuit makers, box-makers, solderers, clerical workers, invoice machine operators, retail saleswomen, etc.

We have just seen that the methods of testing vocational abilities are three in number. We have called the first the method of 'sample' (or 'trade') tests. These tests occur, for example, in the series devised for shorthand and typewriting by the National Institute of Industrial Psychology. For testing shorthand, six passages are read out to the subject at different prescribed rates – 60, 80, 100, 120, and 140 words per minute being successively read to him. Then a series of unusual words of graded difficulty, exemplifying important principles in shorthand, is given to him, which he has to express in proper shorthand outlines and transcribe back into longhand, no time limit being provided. For typewriting, five 'sample' tests are employed – (1) for speed, (*a*) with time limit and (*b*) with amount limit; (2) for accuracy, copying a much corrected manuscript; (3) for display; (4) for tabulation of a complicated list of data; (5) for manuscript reading of two very illegible letters.

The entire test – these 'sample' tests form only part of it – lasts two hours and has been found in practice to correlate highly with the opinions of the supervisors of

the clerks. That is to say, when the ranking of the subjects according to their success in the entire test is compared with their ranking according to the views of their supervisor, there is a very close correspondence. The test has also enabled a list of minimal standards to be prepared, which a candidate must obtain according as (1) he is needed for work of a high order of intelligence, (2) he is required only for routine work, (3) information is desired as to whether after adequate training he is likely to be fit for practical work or is unfitted for any work whatever in shorthand and typewriting.

The following is a good instance, devised by an American psychologist, of the second method of vocational testing, which involves the employment not of a 'sample' test but of an 'analogous' test. In order to examine workers who were to be engaged on feeding machines, a gramophone box was employed, on the circular horizontal disc of which was placed a larger metal disc presenting a small sector which was cut out, and the size of which could be varied. This open sector, while passing over a certain spot, allowed of a shot dropped at that moment passing into a stationary funnel-headed receptacle beneath. When the disc revolved, the candidate had to drop the shot at the precise moment so that the ball fell through the rotating slit into the stationary receptacle. It was found that some workers did better with a slow rate of rotation, whereas others did better with a quick rate; and that this cor-

responded to their varying industrial efficiency with the slow- or fast-moving machines which they had to feed. The same individual differences in optimal rhythm of movement were noted in British munition factories during the war, some workers succeeding better with fast than with slower machines, and others *vice versâ*.

The third method of vocational testing attempts to analyse the various qualities required for success in a given occupation and to test each of these qualities separately, instead of employing the complex 'sample' or 'analogous' tests of the two methods previously described. An illustration of the early use of this 'analytic' method is provided in the examination of twenty-eight telephone exchange girls in Switzerland. The tests finally selected were those for memory of numbers and names, for accuracy of aim, for speed of reaction, for speed and accuracy of cancellation of given letters wherever they occur in a given sheet of printed words, and for speed and accuracy of card-sorting.

The unsatisfactory results of seven of the subjects will receive attention presently. The remainder agreed very closely in order of success at the tests with the order independently ascribed by the telephone supervisor. Here are successively the tests-order and the supervisor's order of ranking. Where two girls, say the 9th and 10th, are equal in the tests they are each given an intermediate rank, 9·5.

1	2	3	5	8	9	10	11	12	13	14	15
3	2	1	4	5	8	13	7	12	9·5	14	11

19	20	21	22	23	25	26	27
16	23	19·5	26	21	22	19·5	25

We are able to measure the correspondence between the ranking by tests and the official ranking by means of a formula giving a coefficient of correlation. This coefficient is zero when there is a total absence of correlation; it is + 1 when the direct correlation is perfect; and it is − 1 when the correlation is inversely perfect, i.e. when the top individual in the one ranking is last in the other, and so on. Between 0 and + or − 1 the correlation coefficient has any value, expressed as a decimal fraction, according to the degree of correlation, direct or inverse. The coefficient in the above tests for telephone operators was + ·698; in those already described for clerical workers it was practically identical, namely +·7.

In an occupation in which breakdowns are frequent from the strain involved, as in telephone-exchange work, it is obvious that much mental and physical suffering could be saved by some such carefully devised methods of selection whereby the unsuited are eliminated at the outset of their career.

[Seven of the telephone operators, as has been mentioned, showed poor correspondence between their ranking according to the tests and according to their supervisor's opinion. Several causes may be responsible

for this. The supervisor may have been wrong in his opinion; a striking illustration of such an error will be given immediately. Or the tests may have been inadequate; there can be no doubt that they are capable of improvement. General intelligence, the determination of which was not specifically attempted here, must play some considerable part in telephone exchange work. How important a part remains to be ascertained; but a highly intelligent individual may be able by roundabout ways to compensate at his or her work for deficiency in one or more of the special abilities which are estimated by these different tests. It will be observed that some tests were included in the examination, which are highly correlated with general intelligence; whereas others, e.g. accuracy of aim and speed of reaction, are not correlated with general intelligence.

Again, each of the tests is given the same weight in determining the final rank of the operator. But more careful research will certainly discover that some traits are more important for telephone work than others. Consequently instead of determining the final ranking by averaging the ranks in each test, certain tests will need to be 'weighted,' thus allowing of greater importance being given to them than to others, in the settlement of the final order based on the results of all the tests. Further, in the present instance the tests clearly need to be supplemented by others, such as the ability to interpret indistinctly heard words. In testing for visual acuity by means of letters, it is found that some

subjects are ready to interpret the vague indications suggested by letters really imperfectly seen, whereas others stolidly read only the letters which are clearly visible. So it is with the discrimination of two near points simultaneously applied to the skin. There is a type of person ready to interpret suggested signs, and another type indisposed to do so. Anyone who has ever heard a foreign language through the telephone will realize the importance of the interpretation of indistinctly heard sounds for successful telephone exchange work.

Lastly, the supervisor may base his opinion of the operators which are to be ranked, on such qualities as obedience, punctuality, patience, and courtesy, which the tests fail to take into account, or may be more or less unconsciously prejudiced in favour of or against some particular operator. Indeed, the marvel is that in all these circumstances the coefficient of correlation should be so high. But we have not yet considered one important factor, which may affect the degree of correspondence in the two ranks – the factor of interest. One of the seven operators, whose ranking differed strikingly in the tests from that of the supervisor, did very well in the tests but was comparatively low in the supervisor's order of ranking. The latter, when her attention was called to the fact, said – 'Well, I am not a bit surprised. The girl could make an excellent telephonist if she only chose.'

In its experience in this country, the National Insti-

tute of Industrial Psychology has met with similar instances. In one case the tests devised for the selection of packers gave much higher coefficients of correlation when they were correlated with the results of a special speed test of packing applied to the girls than when they were correlated with the girls' average output as determined by their piece-rate earnings. Nevertheless this firm estimates that the introduction of vocational tests into its factory has saved it many thousands of pounds per annum. The son of one of the directors is now head of the psychological department at the works and has a staff of several psychologists to assist him in vocational selection and movement study.

On the other hand, there were one or two cases among the telephone operators of girls who did poorly at the tests but were ranked high by their supervisor. Doubtless this is in part to be explained by a lack of interest in the tests or by a failure to do well under experimental conditions.]

In a subsequent research, conducted by the Industrial Fatigue Research Board, into the qualities and tests required for printing compositors, coefficients of $+\cdot 71$ and $+\cdot 80$ respectively were obtained in the correlation between the ranking by the tests and that by the management in two printing establishments. The four tests actually utilized were: (1) a 'cancellation' test demanding close attention, rapid observation and resistance to fatigue, at which the compositor was engaged for two

minutes in cancelling every successive *e* in the meaningless lines of printed French words submitted to him; (2) a 'substitution' test involving, in addition to the foregoing, memory, in which different numbers had to be pencilled within a printed series of different geometrical figures according to the instructions written at the top of the page submitted to him, e.g. within every circle the number 1 had to be placed, within every triangle the number 2, within every star the number 3, and so on; (3) a 'directions' test in which the subject had successively to carry out as many different instructions as he could within a given time; (4) a 'match-board' (or 'pegging') test of dexterity, comprising two tests each lasting 30 secs. (the cribbage-like board being placed in the first test at arm's length, in the second much closer to the body), the subject having to insert into the holes on the board as many small pegs or matches as possible within the time given (cf. Fig. 17, page 134). Unfortunately, owing to difficulties in scoring, it was found necessary to omit the results of (5) a valuable form-board test, in which wedge-shaped blocks, resembling the 'quoins' used by compositors to fill spaces in the compositor's 'case,' had to be inserted into a board from which spaces of corresponding size and form had been cut.

By the method of partial correlation the extent was determined to which these different tests involved the same capacities, the correlations between the tests themselves being calculated as well as between each test and

the composing efficiency, i.e. the ranking by the management. It thus proved possible to weight the importance of the various tests and to reach the already-mentioned results, which are indeed remarkable seeing that composing efficiency depends also on such here untested factors as trade knowledge, honesty, duty, interest, ambition, etc.

Since these pioneer efforts, the National Institute of Industrial Psychology has devised several series of tests for dressmaking, embroidering, weaving, engineering, salesmanship, etc. (see page 116). These are now being successfully applied to the selection of apprentices in some of the largest firms in the Kingdom. The workers appreciate the greater fairness which results from such testing and are interested in carrying out the tests, many of which, they say, resemble their ordinary work. The supervisors are unanimous in regard to the helpfulness of the tests. They comprise both the analogous and the analytic (cf. page 114) forms of test. They have been constructed according to the following principles:

The investigator first familiarizes himself with the occupation for which the selection tests are required. By studying good and bad workers, by conversing with the foremen and supervisors, and by actually engaging in the work, he ascertains the special qualities which appear likely to be required for success in the occupation. Then he devises appropriate tests for these, carefully avoiding the use of sample tests (cf. page 114); for

any previous familiarity with them would give a subject an advantage over subjects to whom they were quite new. Care is taken, on the other hand, not to make any test too abstract, as it would then be far removed from working conditions. Any one test, therefore, generally demands and measures more than one elementary mental function; indeed it sometimes becomes difficult to draw any boundary between the analogous tests and the analytic tests thus devised. Their purpose is to estimate innate, not acquired, abilities – in other words, talents, not attainments.

Next, the texts have themselves to be tested upon a group of workers, good, bad and indifferent, whose workshop efficiency is at the time unknown to the investigator. The ranking of these workers according to the tests (properly weighted, cf. page 120) and their ranking according to the foreman or supervisor are compared. If a good correlation is found between the two orders, if, say, the coefficient of correlation (cf. page 119) does not fall below $+\cdot 7$, the investigator proceeds to the next stage of his work. If, however, the correlation is poor, he endeavours to improve his tests, he considers whether he has weighted the various tests fairly, or he scrutinizes more closely the reliability of the foreman's estimate of his workers.

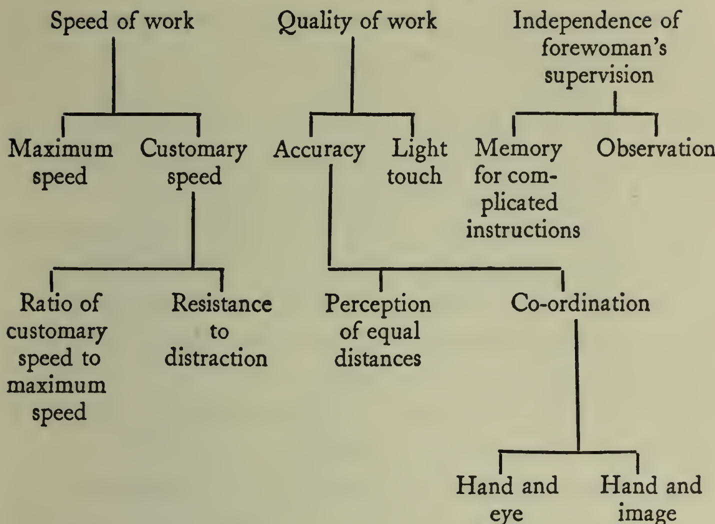
Finally, the selected tests must be standardized by their application to a large number of persons of the same age, sex and standing as those who are likely to seek the occupation in question. By this means know-

ledge is obtained both of the average marks which a sample of the general population of applicants should be expected to attain in the various tests, and of what constitute a fair, a good, a poor or a bad performance of the tests. The tests are then ready for practical application.

Some of them are 'group' tests (i.e. they are each applicable to a group of persons); others are 'individual' tests. The chief advantage of the former lies in the saving of time; while the latter are specially valuable, as they allow of observations as to how each subject sets about his task and enable the investigator to converse with him. In every case, however, an interview is given, if possible both before and after the testing, the special qualities that need to be ascertained, e.g. leadership, energy, etc., having been carefully selected in advance, and grade-letters being accorded to every subject for each quality according to the following scale:

A – very good	(top	5%	of	the	candidates)	
B – good	(next	25%	,,	,,	,,	)
C – average	(,,	40%	,,	,,	,,	)
D – less than average	(,,	25%	,,	,,	,,	)
E – very weak	(bottom	5%	,,	,,	,,	)

The following table represents the analysis by the Institute of those psychological factors, amenable to testing, which appear to determine the efficiency of dressmakers' apprentices.



Ten tests for these qualities are applicable simultaneously to a group of twenty-four girls, taking fifty-five minutes for their application. They include speed tests in knotting, threading and pricking, tests for good quality of work in the perception of parallel lines, in bisecting lines, in co-ordinating eye with hand movement and in lightness of touch, and tests of observation and of memory for dress design and details. The tests are thus carried out:

A. SPEED TESTS.

1*a*. *Wool.* The first test is for distractability and 'ordinary' speed, and is given before the girls have any reason to suppose that speed tests will

be required of them. They are told ('there is no hurry') to make knots in a piece of wool at their own rate. The examiner introduces the effect of distraction by explaining during the test the general purposes of psychological testing.

The tests for maximum speed are:

1*b*. *Wool*. Knotting wool as in the preceding test, but at maximum speed and without distraction.

2. *Beads*. Threading beads at maximum speed.

3. *Pricking* with a mounted needle at maximum speed.

B. TESTS FOR QUALITY OF WORK.

The candidate's power of discriminating equal distances is measured by two tests:

4. *Parallel Lines*. A sheet of paper is shown to the candidate on which are drawn thirty-two pairs of lines, some of which are exactly parallel and some of which are nearly but not quite parallel. She has to select which pairs are exactly parallel.

5. *Bisection*. The candidate is given a limited time in which to bisect a given line 'by eye,' then to bisect the halves, and then the quarters.

6. *Aiming with pencil*. The test for hand-and-eye coordination consist in aiming with a pencil at certain points on squared paper at a given rhythm.

7. *Aiming with pin*. The test for hand-and-image coordination is the same as the last, except that a pin is aimed at the points from beneath the paper.

8. *Tissue paper.* The candidate's lightness of touch is ascertained by giving her a square of tissue paper to fold as if it were being hemmed.

C. TESTS FOR EASE OF LEARNING WORK.

9. *Fashion Plates.* The powers of observation of the candidate are determined by showing her two fashion plates for a very short time and then seeing how complete a description of them she can give.
10. *Instructions.* In order to find the candidate's memory for complicated instructions, a description of a dress is read to her, and after a quarter of an hour's interval she is asked to write down as much of it as she can remember.

These group tests for dressmaking (together, of course, with tests of vision and a medical examination) may in some cases be followed by individually applied tests. They have been found so valuable that the Institute has been asked to formulate others adapted for the selection of girls for the tailoring and millinery trades. At the request of a County Education Authority the same tests have been introduced into the scholarship examination of girls who are to be selected for a Trade School.

Similar tests have been devised by the Institute at the invitation of a firm engaged in embroidery, tapestry-weaving, and the like. Some of the tests for embroidery

resemble those for dressmaking, but other special abilities need to be estimated, e.g. the speed of large movements of the arms (cf. Fig. 13).

In tapestry-weaving separate tests have been devised for the following qualities which were found desirable for an efficient worker – disparate attention (i.e. the ability to attend to several objects or themes at the same time), discrimination of and memory for patterns, discrimination of thickness of yarn, fine threading movement, speed and length of turning movement and ability to plan ahead. These tests are given individually and take about half-an-hour to apply to each candidate. The test for fine threading movement is shown in Fig. 14, the time being estimated which is taken in threading a stiff piece of wire through a succession of eyelets suspended from a frame. The tests for turning movement consist in twisting up a screw with the right and left hands, the hands being held in the position in which new warps are twisted on to the loom. (Before a girl can receive a bonus as a 'twister,' she must be able to make over a thousand twistings per hour.) As the twisters work from both sides of the loom, some are trained to use their right, others their left hands. The tests for turning movement are thus also valuable for the indication they provide as to which hand should be trained.

Only a small number of weavers (thirteen) could be tested; but so far as they go, the data thus obtained indicate a satisfactory correlation (+·77) between success at the tests and the manager's ranking.

FIG. 13 (W. Spielman).

The movements consist in transferring the rubber thimbles from the further to the nearer pegs.

[*To face p.* 130.

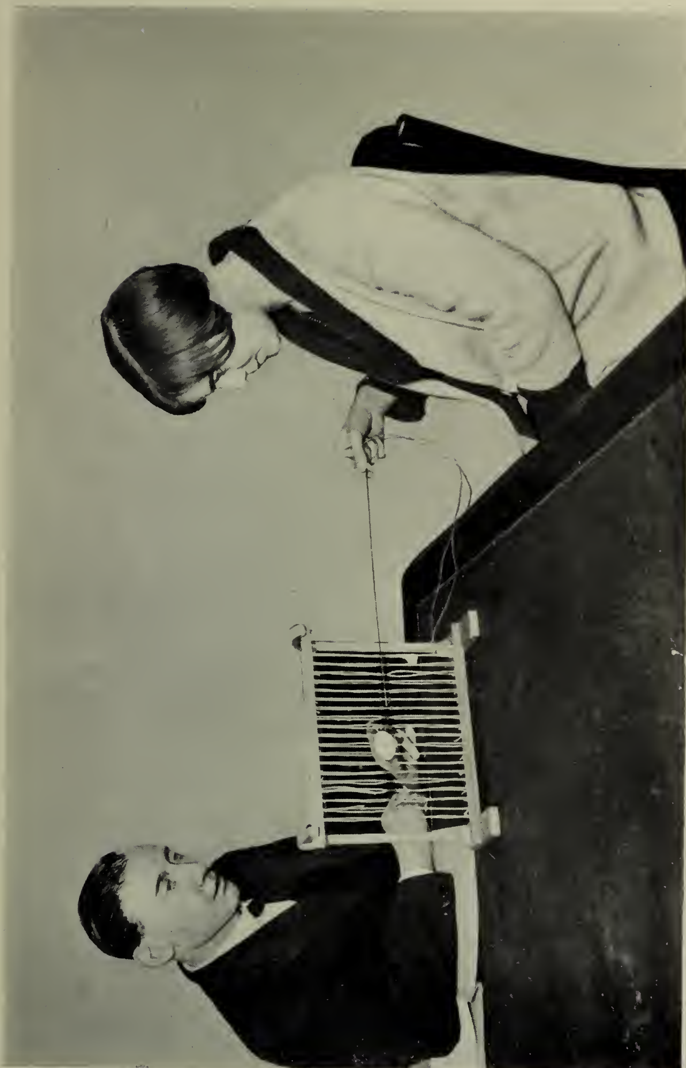


FIG. 14 (W. Spielman).

[*To face p.* 130.

[For the Institute's tests for ability in piping and icing confectionery (putting icing sugar between and on cakes, etc.), which were applied to nineteen experienced workers, a correlation coefficient of $+\cdot 84 \pm \cdot 04$ (the latter figure indicating the probable error of the coefficient) was obtained between the ranking according to the tests and that by the firm. The following table shows the actual correspondence in ranking, the girl who was placed first by the firm coming out third in the tests, and so on:

The Firm's Ranking:	1	2	3	4	5	6	7½	7½	9	10
The Tests' Ranking:	3	1	9	2	5	6	4	12	11	10

The Firm's Ranking:	11	12	13	14	15	16	17	18	19
The Tests' Ranking:	7	17	16	14	15	8	13	18	19

Tests for packing ability, applied to the same number of other workers, gave a correlation coefficient of $+\cdot 86 \pm \cdot 04$, and the following ranking as compared with that by the firm.

The Firm's Ranking:	1	2	3	4	5	6½	6½	8	9	10
The Tests' Ranking:	1	3	4	7½	7½	2	6	16	9	13

The Firm's Ranking:	11	12	13	14	15	16	17	18	19
The Tests' Ranking:	5	10	11	14½	17	12	14½	18	19

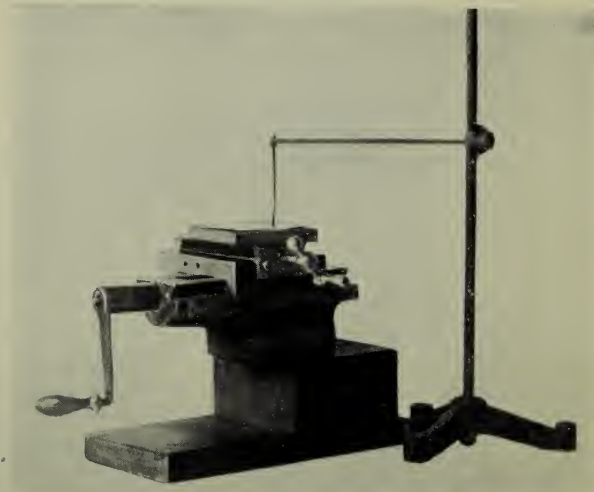
The packer who according to the firm ranked eighth proved to be a very excitable girl at the tests, dashing at them with such speed that a special inquiry was made as to whether the tests had afforded her a fair trial.

For practical purposes, of course, it matters little

whether there is a slight discrepancy between the two rankings. The important point is whether, taking the pass level of skill, say at the first eleven (i.e. 60 per cent.) of the girls, there are any skilled girls who fail to pass the tests, and any relatively unskilled girls who succeed in passing the tests. Among the thirty-eight girls included in the above two tables, there are only two such exceptions, one of which is readily explicable. In the remaining thirty-six girls, correct placing is made in every case.]

A series of engineering vocational tests has been recently employed by the National Institute of Industrial Psychology in order to eliminate those lads unfitted for engineering work. They have been adopted by certain firms also with the object of determining which branches of the trade – draughtsmanship, turning, fitting, pattern-making, machine-operating, etc. – each apprentice is best fitted or least fitted to take up. They serve to indicate the special abilities which the apprentice possesses, and require to be supplemented by tests for general intelligence, by a medical examination into his physique, by an interview at which his temperamental qualities are assessed, and by inquiry into his education attainments.

These tests for special engineering abilities, several of which have originated in America or in Germany, are planned to reveal visual imagery, perception and memory of spatial relations (size and shape), motor co-



FIGS. 15 AND 16 (M. Tagg).

[*To face p.* 133.

ordination and dexterity, mechanical ingenuity, adaptability, and disparate attention (cf. page 130). The following are among the most useful tests for this purpose – inverse drawing, cube-building, strip-building, form board, form-building, drilling-machine tests, slide-rest test, assembly test, and divided-attention test.

Of these, the inverse-drawing test consists in making a drawing of the inverse of a simple diagram, as if it were seen in a mirror; in the cube-building test a large cube has to be built up as quickly as possible from a number of smaller cube-bricks, one or more sides of which are painted in a given colour, so that all four sides of the larger cube are so coloured; the strip-building test consists in fitting into a tray successive pairs of pieces (selected from a number of varying length) which together just make up the width of the tray; in the form-board test wooden pieces of different areas have to be fitted as quickly as possible into a board in which holes of exactly corresponding size have been made; in the form-building test, four metal pieces of different size and shape have to be fitted together to form a rectangle; the drilling-machine test (Fig. 15) requires the candidate to spot the centre of a one-inch circle (previously drawn on a movable paper) with regard to the needle placed in the chuck of the machine; in the slide-rest test (Fig. 16) the paper bearing an outline design is fixed and the candidate is required to trace over it by working the two screws (giving to-and-fro and side-to-side movements respectively) of the slide-rest; in the

assembly test the time is recorded for assembling a series of simple mechanisms, such as a lock, a bell, etc.; in the divided-attention test (Fig. 17), the candidate has to tap with one hand and to insert pegs into a cribbage-like board (cf. page 123) with the other as fast as possible, while from time to time the investigator presses a key which brings over the red disc of an indicator, whereupon the subject has at once to stop pegging and to depress a key which will replace the disc.

These tests appear to show different degrees of positive correlation with known ability in different branches of the engineering trade. The following table indicates some of the more striking differences, which were obtained from over a hundred youths of about sixteen years of age in various engineering schools:

Test.	*Correlation with Trade Abilities.*
Inverse drawing.	Draughtsmanship ·82 ± ·02. Machine operating ·42 ± ·05.
Cube building.	Fitting ·72 ± ·03. Turning ·57 ± ·04.
Form building.	Draughtsmanship ·72 ± ·03. Machine operating ·42 ± ·05.
Strip building.	Machine operating ·72 ± ·03. Tool making ·54 ± ·04.
Drilling machine.	Machine operating ·70 ± ·03. Draughtsmanship ·43 ± ·05.
Divided attention.	Machine operating ·81 ± ·02. Pattern making ·45 ± ·05.

FIG. 17 (M. Tagg).

[*To face p.* 134.

Assembly.	Fitting $\cdot 81 \pm \cdot 02$. Draughtsmanship $\cdot 59 \pm \cdot 02$.
Slide rest.	Turning $\cdot 62 \pm \cdot 04$. Pattern making $\cdot 39 \pm \cdot 05$.

In the hands of a trained investigator these tests, being administered individually, serve also to estimate certain important traits of character, such as patience, thoroughness, systematic methods of work, etc. Indeed differences of temperament appear to be fully as important as any others in determining the particular branch of engineering to which a given applicant for guidance is fitted.

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Chapter 5

VOCATIONAL GUIDANCE AND SELECTION (*continued*)

THE following illustration of the value of engineering vocational tests, derived from the United States, is of interest for several reasons. A selection had to be made among apprentice tool-makers and machinists, of those best fitted for a course of intensive training. The foreman ranked twelve of these men on two occasions, at first in accordance with his original estimate of their abilities, and later according to his final estimate of them after several weeks' close intimacy during the period of their training. Meanwhile to the chosen apprentices the following series of tests was applied – (1) a cube-building test (see page 133), (2) an assembly test (see page 134), (3) a form-board test (see page 133).

The combined ranking obtained from these tests corresponded very indifferently with the *original* ranking by the foreman; but it corresponded very closely indeed with the *later* ranking by the foreman after he had had several weeks' experience in instructing his apprentices. The correlation between the tests and the foreman's first ranking was only +·28, whereas between the tests and his second ranking it reached +·9, perfect correlation being, it will be remembered, unity.

Here are examples illustrating the discrepancy between the foreman's two rankings and the successful ranking by the tests. A pleasant, willing youth, first ranked by the foreman as fourth, but later as ninth, came out ninth in the tests; an overgrown, 'slip-shod,'

dreamy-looking youth, first ranked by the foreman as tenth, but later as fifth, came out first, second, and fifth in the three tests, respectively; another apprentice, ranked first as eighth, later as fourth by the foreman, came out fourth in the tests; yet another apprentice, ranked successively as fifth and twelfth by the foreman, came out eleventh in the tests. It may be argued that this particular foreman happened to be exceptionally ignorant, at the start, of the abilities of the apprentices under his charge; but such ignorance is far from uncommon, and it is preferable to stress the great help which can clearly be rendered by systematic tests towards selecting the ablest candidates for a given job.

So high a correlation, however, as ·9 is always open to suspicion, especially when derived from observations on so small a number of subjects. The same results need to be obtained from many other groups to be accepted without qualification. Unfortunately when this is done, the too common experience is that the degree of correlation shows a very high variation among different groups to which the same tests are applied. Indeed the variability is far greater than would be expected from calculation of the probable error. This is partly due to the different character of different groups. Some groups may be far more homogeneous than others, and therefore show a poorer correlation with the tests applied; for it is obvious that if the candidates are nearly alike in ability, the tests cannot be expected so easily and so accurately to differentiate the better from the worse as

when the candidates show wide differences in ability. Moreover, a candidate's attitude towards any given test or towards testing as a whole is likely to vary from day to day; finally, for various reasons (especially owing to bygone long-forgotten experience) the special form of a given test may make a particular appeal, or may prove particularly objectionable, to a given candidate. Such are some of the obvious causes of the low reliability of coefficients of correlation.

Of the vocational selection tests which we have so far described, some (e.g. memory for numbers) may be classified as purely mental tests, others as tests of manual dexterity, others again as tests of mechanical ability ('machine sense'), etc. Each has been devised to test the special native abilities involved in some special occupation. In a research by the National Institute of Industrial Psychology into vocational guidance, similar tests of manual dexterity, e.g. bead-threading, wool-knotting, pegging (with different fingers, with different numbers of pegs in hand, with and without vision), tapping (speed test), screw-turning, and picking up a prescribed number of pencils simultaneously, are being employed, and an assembly test is included as indicative of mechanical ability.

In the same investigation a special test of interests is also being given, in which the adolescent subject has to write answers to a series of questions framed to elicit his general acquaintance with (and presumably

his interest in) the technique of various occupations.

Further, the temperamental qualities of each subject are assessed independently by more than one investigator, a grade letter (cf. page 126) being given for each such quality as neatness, cleanliness, expression, assertiveness, ambition, initiative, leadership, constructiveness, self-criticism, self-confidence, calmness under pressure, control of attention, energy, persistence, reliability, industriousness, co-operativeness, sociability, tenderness, curiosity, sex development, emotionality, shyness, nervousness, and the like.

A careful inquiry is also being made into the home and family circumstances of each applicant for vocational guidance, and a medical examination is conducted, especially with the object of revealing contra-indications in regard to occupations that demand much standing, sitting, climbing, exposure, indoor work, muscular or nervous strain, dusty atmosphere, dry hands, good sight, hearing, etc. The applicant's scholastic attainments and his teacher's report on his character and intelligence have also to be taken into account.

It is of especial importance to test the general intelligence of each subject, inasmuch as the teachers' estimates may be far from accurate and because different occupations demand very different degrees of general intelligence for success. Indeed, as we shall presently point out, such occupations as clerical work need a different kind of test for general intelligence from that required for 'manual' work. Each subject is therefore

submitted both to 'linguistic' and to 'performance' tests of general intelligence. These will be described later (pages 154–6).

Lastly and of equally great importance for vocational guidance is the inquiry which must be made into the general or special qualities required for success in the principal occupations which an applicant is likely to adopt (job analysis), and into the number of vacancies that are likely to occur in them.

The devising of tests to estimate character has been carried out mainly among children, and mainly by investigators in the United States. There, for example, children have been asked to rank a number of offences in what appears to them the right order of wickedness. Other investigators have observed the frequency with which a given child will base his action, when confronted with a given situation, on moral, rather than on non-moral, grounds. Others, again, have issued questions to children as to the amusements they prefer, their thoughts when alone, their tastes for jewellery, clothes, etc., their ideals of spending money, etc. Tests have even been applied to discover how often a child will yield to temptation when cheating is possible, e.g. in tracing mazes with the eyes shut, in carrying out tests when the key to them may be easily referred to, etc.

In Great Britain, however, reliance has hitherto been placed almost entirely on past records and on the inter-

view for the purpose of estimating moral and temperamental qualities. The general belief here is that, in so far as we cannot observe a person's complete character by the accuracy, thoroughness, system, perseverance, neatness, etc., which he brings to bear on any individual test, we are at present, at least, thrown back on the interview. The recent efforts to make the interview more systematic, to instruct the interviewer as to what qualities he has to look for, and to establish rating scales for them, together with a comparison of the results of subjecting the same person to different interviewers, cannot fail to improve our methods of determining and estimating temperamental and moral qualities.

We are now in a position to review the respective uses and to estimate the relative values of the three methods of vocational testing which we have distinguished – (*a*) by sample tests, (*b*) by analogous tests, and (*c*) by analytic tests for specific abilities revealed by analysis of the occupation. For several reasons, sample tests are unsuitable for vocational guidance. In the first place, the tests have to be carried out in a laboratory and have to cover so wide a range of possible occupations, that it is clearly impracticable to instal there all the various appliances, machines, or instruments which will provide the experimenter with a sample of the work in each of all these occupations. In the second place, the results of the tests, even when used for selection purposes, will be seriously disturbed by individual differences of ex-

perience. Thus for the vocational guidance or selection of a youth who proposes to take up engineering, the introduction of an actual lathe to test his ability will be obviously to the disadvantage of one who has never had the opportunity of previously using it, compared with another candidate who has long been doing amateur work with it. So too in testing girls for needlework ability, actual tests in needlework can throw little light on innate ability, when the results are complicated by individual differences of past experience. In the third place, the prime object of our tests is to ascertain inborn abilities, not acquired attainments.

On the other hand, analytic tests may be too abstract or too incomplete to provide an adequate estimate of the candidate's fitness for a given occupation. Care should be taken lest they be too far removed from industrial conditions, or lest they provide only a small fraction of all that is required for success in every-day, 'concrete' circumstances. They run a risk of becoming tests of formal ability, the same test being applied to determine apparently the same ability in widely different operations. The validity of the results of such a test may be compared to the validity of a test for some special form of memory when it is applied to ascertain the degree of quite another form of memory. We know that the ability to learn quickly, and to reproduce accurately, say a series of nonsense syllables is by no means identical with that of learning quickly and reproducing accurately, say the substance of a story. Against

this notion of measuring memory, attention, or the like by a single test, psychologists have for many years past successfully protested. Moreover, an individual organism is something indivisible by the very fact of its organization; the whole is not the mere sum of the abstract parts into which analytic psychology may divide it.

Lastly, the more abstract the test, the greater its simplicity, and (often – not necessarily) the less call it makes on the higher mental levels. This is probably the explanation of the surprising results which have been obtained in two independent inquiries conducted into the correlation of various motor abilities with one another. In one of these inquiries several groups of adolescents and young adults were tested for speed of tapping, accuracy of aim, dexterity in inserting match sticks into holes, deftness of movement, auditory reaction time, total muscular strength, etc. It appeared that these tests were correlated only in a very small degree with one another – very seldom higher than + or — ·2 and in many cases about + or — ·05 or less. Repeated application of the tests showed that this result was not attributable to any low reliability of the tests; on the contrary, high coefficients of reliability were obtained. Moreover, practice at the tests failed to produce any increase in the amount of inter-correlation. The conclusion seemed justified, therefore, that there is no such thing as general 'motor dexterity' or 'practical ability,' that motor capacities vary apparently in inde-

pendence of one another, so that an individual's performance in any one form of motor activity affords no indication whatever of what his performance will be in another form of motor activity. In other words, experiment appeared to indicate that 'there is no "motor type."'

Such a conclusion is, of course, in direct opposition to everyday experience. The man who excels in one form of game or sport is likely to excel at another, he has in general a 'good eye,' or his movements in general are 'cleanly' executed; we speak as confidently of 'general motor ability' as we do of 'general intellectual ability.'

This brings us to consider the whole question of general ability. Let us bear in mind that the first attempts to determine general intelligence by mental tests involved the use of tests of low-level abilities, e.g. of the spatial threshold (i.e. the smallest distance between two simultaneous touches on the skin so that they may be experienced as a double touch) or of the appreciation of slight differences in lifted weights. Psychologists in France, in America, in England, and elsewhere then believed that such tests afforded an indication of intelligence. Even tests of speed of tapping and of reaction time had a similar reputation. But later and more careful work has shattered it. Discriminative ability in regard to the higher senses of vision and hearing does appear to show some correlation with intelligence; e.g. the speed of cancellation of a prescribed letter, and the delicacy of pitch discrimination,

have proved of value. But tests involving the lower senses and simple movements show no correlation with intelligence. The pioneer work, first begun in 1883 in England and extended during the following decade in the United States, which finally resulted in schemes of tests being applied to students of Columbia University, led to disappointing results. Little correlation was obtained between these 'low level' tests themselves, or between them and the class marks of the University students.

The same cause is doubtless responsible for the results to which we have already drawn attention in the sphere of movement. The tests were too simple to show any general ability. They appealed to too low levels of the mental and nervous system, and offered no proof for or against any integration of motor abilities at higher levels. Such results make us chary of carrying analysis too far in what we have called 'analytic' tests for industrial purposes. They need to be devised and to be interpreted with a caution which can only be expected from experts adequately trained in psychological principles.

In testing for intelligence the same results are clearly indicated by history. Simple sensory and motor tests have here proved almost of as little value as earlier and recent attempts to determine intelligence by facial features and expression, to deduce mental characters from the relative prominence of different regions of the skull, or to rely on the size, shape, and symmetry of the head,

nose, palate, ears, etc., as stigmata of degeneracy. As has been well said, '*judge mental functions by mental symptoms*, *not by physical*.' And it may be added, judge the higher mental functions by tests which are complex rather than simple. Such has been the trend of the development of intelligence and other tests. Simple tests, e.g. tapping and free association, have their uses; but for higher-level testing they need to be supplemented by higher-level tests, e.g. aiming in place of dotting, and constrained association (where practically only one correct answer can be given), e.g. replies of opposites, synonyms, and analogies, in place of free association.

By intelligence we mean foreknowledge of and adaptability to changes in environment, present and coming, the conscious employment of past and present experience. We thus distinguish it from the flash of intuition or the inspiration of genius, where decisions are made, or new ideas are created, unconsciously. Intelligence involves conscious analysis and synthesis – the conscious differentiation or abstraction of likenesses and differences, and the conscious use of generalization and inference. It demands the 'seeing' of relations and the immediate realization of the value or use of that seeing.

The first series of general intelligence tests came from France. They are known as the Binet-Simon tests and were originally intended to sift out school children believed to be mentally defective. These tests are given to each child individually and are arranged in groups

according to the child's age, the age varying from three to sixteen years. They involve general information, memory, imagery, carrying out instructions, and answering problems that require the use of discrimination, definition, rhyming, naming, copying, counting, etc.

Various improvements have been made in these tests, but perhaps the most striking advance has been in the substitution of group tests for individual tests of general intelligence. These laboured at first under the disadvantage that, as a rule, they were unsuited for children below ten years of age, but this drawback is in process of being largely overcome. The greatest objection to group tests, the impossibility of observing the behaviour of each subject and getting an insight into his mind, can be easily remedied by arranging for an independent interview. The overwhelming advantages of the group test consist in the enormous saving of time, in their applicability by persons having relatively little previous training (whereas 'individual' tests need to be administered by an expert psychologist), and in their suitability for adolescents and adults.

The group tests of general intelligence are for the most part of American origin. Those which have been standardized in Great Britain by the National Institute of Industrial Psychology include the naming of opposites (e.g. 'found' for 'lost,' 'capricious' for 'reliable'), the discovery of analogies (e.g. 'when is to where as time is to' – 'space'[1]), the apprehension of the truth or

[1] The word space has to be supplied.

falsity of 'mixed' sentences (e.g. heat solids necessary is to certain melt), the completion of sentences from which certain words have been omitted, and problems involving reasoning.

The following interesting account of the use of such group tests in this country is worth citing from a report recently issued by the Board of Education:

'The method of group-testing has been employed, upon a small and experimental scale, by school teachers and scholarship examiners in England. The Bradford Education Authority in 1919 adopted, for the purposes of junior scholarship examinations, a number of the written group tests first used in 1911 for an early research at Liverpool. Two years later, at the request of the Northumberland Education Authority, Professor Godfrey Thomson devised a set of group tests for much the same object in what was one of the most notable experiments on the subject in this country. It had been observed that nearly one-third of the schools in the county of Northumberland presented no candidates for the ordinary scholarship examinations in English and Mathematics. These schools were largely small schools in isolated rural districts, such as the Cheviots and the Dales; and it appeared possible that, from lack of home culture, of town life, and of teaching facilities, many of the best county pupils might be handicapped in essay-writing and arithmetic. Three thousand children were accordingly tested; and it was found that many of the most successful pupils resided

in the remoter areas of the county. This early experiment was so successful [1] that a group-test of intelligence has since been introduced on every occasion into the Northumberland examinations for such scholarships.

'Similar difficulties have been encountered by other English education authorities; and have been dealt with experimentally by similar means. Dr. Ikin, Education Officer for Blackpool, has tested a group of one hundred scholarship candidates for Junior County Scholarships with five of the better-known group tests (the Terman, Otis, Northumberland, Simplex, and National Scale respectively). At Rugby, Mr. Vaughan has applied a set of group-tests, devised in London,[2] first to certain selected forms and later to the whole of his school. At Cheltenham Grammar School, Mr. Dobson has applied the same tests (with others) both to the entire school and to candidates for scholarship and entrance. These are but a few of the more notable experiments upon these lines. Where the results have been statistically analysed, it is found that the calculated correlations show a close correspondence with the results of independent scholarship examinations or of independent personal judgments. Where the tests and the scholarship examinations disagree, subsequent

[1] Of twenty pupils selected solely on the ground of intelligence tests, nine took first place in their respective classes in Secondary Schools, and eleven took second or third places.

[2] By Professor Cyril Burt for the National Institute of Industrial Psychology.

study of the children shows that the test has often revealed inborn ability which the scholastic examination failed to detect, owing to the child's lack of opportunity, at school or at home, for acquiring the necessary knowledge. None of the investigators, however, has as yet claimed that intelligence tests can do more than supplement written examinations of the ordinary scholastic type. Before a child can be admitted to a Secondary School he must possess a certain minimum of educational knowledge; and this is to be gauged, not by a test of mental capacity, but by a test of scholastic acquirements.

'Group-tests have also been introduced into examinations for adults. At the London Day Training College, psychological tests have been employed for the last two years as a supplementary means of selecting candidates for the four-year course of training for teachers.[1]

[1] The candidates are young men and women between the ages of 17 and 19. A preliminary experiment was made in 1922, and the results were sufficiently useful to warrant an extension of the method. In 1923 all applicants took a half-hour's test-paper, similar to that devised for the Civil Service competition (used also experimentally at the Bristol University Department of Education and at several other Training Colleges). The evidence relied upon in estimating a candidate's merits is thus derived from three sources: first, the report of his secondary school; secondly, the impression produced by him during an interview – the interview itself being partly standardized in form; and, thirdly, the results of the psychological test. The test-results are valuable, not only as an independent source of information about individual candidates, but also as a means of equating the varying standards of assessment

'At Bedford College, since 1921, the Psychological Department has tested incoming students of different faculties with tests designed to measure "Arts" ability, "Science" ability, and "general ability" or intelligence. At University College, the staff of the Psychological Laboratory has similarly employed group-tests to test the intelligence of freshmen who have volunteered to sit for the examination. These experiments are still too recent for any adequate comparison to be made with the subsequent academic careers of the candidates. In this country, however, the most extensive use of such group-tests has been the introduction of a psychological test-paper into the competitive examination for clerical posts in the Civil Service in 1920 and the following years. Nearly 40,000 candidates have been so tested; and an analysis of the published mark-lists shows that the psychological test correlates with the general results more closely than any other single paper.'

These group-tests, when answered and marked, give an indication of the intelligence of those to whom they are applied. But it is clear that success in answering them does not depend merely on intelligence. For example, two persons of equal intelligence would not necessarily respond with equal speed to a series of words

implied in the reports from the different secondary schools. The estimates based independently upon each of these three methods will ultimately be compared with subsequent progress of the candidates in their academic and professional work.

with their opposites and synonyms. That is to say, the tests are dependent on other abilities besides intelligence. Further, the kind of intelligence required for success in one test is probably by no means precisely that required for success in another. Hence the total marks obtained by a given individual in a group-test merely indicate the mean value of his intelligence as employed in a number of different operations. In other words, intelligence (like memory) needs to be tested not by a single test but by a battery of tests which have been shown to be varyingly correlated with one another.

[From the character of this correlation, however, the deduction has been drawn that such tests measure a single general factor and that this factor of general intelligence depends for its manifestation on a certain fund of energy which varies with the general intelligence in different individuals and can be drawn on differently by different individuals according to the special abilities with which they are endowed. This view presupposes a 'general' factor of intelligence, varying in amount, and numerous 'specific' factors varying not only in amount but also (at all events for practical purposes) in number in different individuals. There may also be several 'group' factors intermediate between the one general factor and the many specific factors, any one group factor being concerned in the function of several specific factors.

This hypothesis of a general factor of intelligence mainly rests on a mathematical basis which seems by no

means secure and has been built on a basis of equally uncertain hypotheses, such as, e.g., that a fund of energy is to be found on the afferent side of the central nervous system which can be drained now into one, now into another, of the efferent channels, and that efferent inhibition is merely the result of drainage of energy into motor paths other than those which suffer inhibition (cf. page 50). Such hypotheses, however, are unlikely to receive physiological support, and we should therefore be content to accept with caution, and merely as a useful working hypothesis, the supposition that any general factor exists at all.]

We are certainly not justified in assuming it to be proven that there is but one general factor involved in all the manifestations of intelligence. At first sight this warning appears to receive striking support from the fact that success attained in the linguistic tests for general intelligence is by no means necessarily identical with that attained in certain performance tests of general intelligence. Indeed the latter are now being expressly employed in order to correct the undue emphasis on verbal modes of expression which is inevitable if reliance be placed solely on such linguistic tests for general intelligence as have been described on pages 148–9. Most of the performance tests employed in this country have been introduced from America. The following are the more important of those which have been selected by the National Institute of Industrial Psychology for use in its research into vocational guidance:

FIG. 18.

[*To face p.* 155.

(1) Maze Test, consisting of eleven mazes, progressively increasing in difficulty and standardized for different ages, the subject having to find his way out of each maze.

(2) Cube Imitation Test, in which four cubes are placed before the subject, and the examiner touches them with a fifth cube in varying order which the subject has to imitate.

(3) Two Form Board Tests, where a series of figures (circle, semicircle, star, triangle, cross, diamond, etc.) have been cut out of a board, the subject having to replace these pieces in the corresponding holes in the board.

(4) Substitution Test, already described on page 123.

(5) Two Picture Completion Tests (cf. Fig. 18), in which holes have been cut from the picture, thus removing some essential object in it, and pieces have to be selected by the subject from those provided and fitted in so as to make sense with each picture.

(6) Profile Test, in which eight pieces of wood have to be put together to represent a man's face in profile.

Such performance tests give ample opportunity for noting temperamental characters. Observations as to how the subject carries out the test may yield information as important as determinations of the amount or speed of his work. Performance tests are of special value in vocational guidance work when it is required to ascertain a subject's intelligence as applied to manual work. Indeed the ratio between the subject's success in

linguistic and performance tests may afford valuable indications for a decision as to his fitness for 'practical' or 'intellectual' work.

These divergent results of comparing the general intelligence of the same set of individuals as estimated now by linguistic, now by performance tests, at first sight support the popular view that there is more than one kind of intelligence – a literary intelligence, a motor intelligence, a mathematical intelligence, etc. It might be thought that each intelligence requires appropriate tests to elicit it, and that the unsuitability of the tests used may be in part responsible for the apparent lack of growth of intelligence after puberty has been attained. But it is still open for those who believe in a single factor to aver that its manifestation is different in different subjects owing to their different endowments with different – literary, motor, mathematical, philosophical – abilities which make use of it.

It may well be that both the upholders of a general factor and the upholders of special factors of intelligence are right, and that each side is only wrong in denying the truth of his opponent's contention. On general grounds it seems probable that there is a specific factor of intelligence in each 'species' of intelligent operation, that there is also a group factor in each 'genus' of intelligent operation, and that over all there is a general factor of intelligence peculiar to the individual's 'self' for *every* kind of intelligent operation.

However this may be, the intelligence tests now in use

have proved of the greatest value in actual practice. No doubt in their present stage individual cases of hardness occur, but that must happen under any system of examination. They afford on the whole a satisfactory rating of the intelligence of the individual – certainly a more satisfactory method than any other we possess; and they indicate the maximum and minimum requirements of intelligence demanded for success in different occupations (we know now that too much intelligence may be as great an obstacle to success in a given occupation as too little). They have proved of the greatest assistance both in vocational guidance and in vocational selection, and the success of their further developments may confidently be regarded as assured.

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